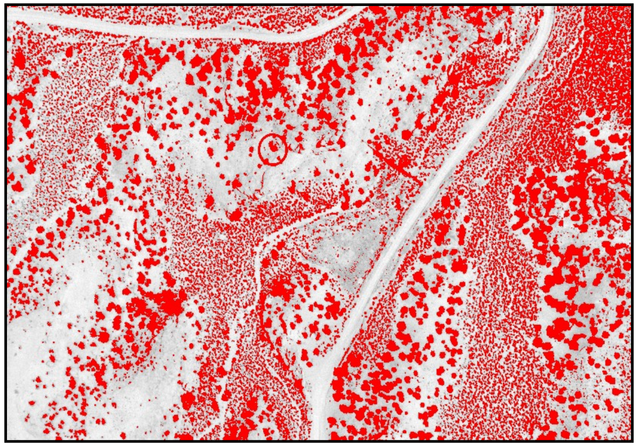
High-Resolution Image-Processing Techniques for Measuring Objects and Detecting Change in Arid Landscapes



By

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Bechtel Nevada

Las Vegas, NV

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Nevada Operations Office, under Contract No. DE-AC08-96NV11718. **DOE/NV/11718--599-VG.**

Cooperative Research Effort

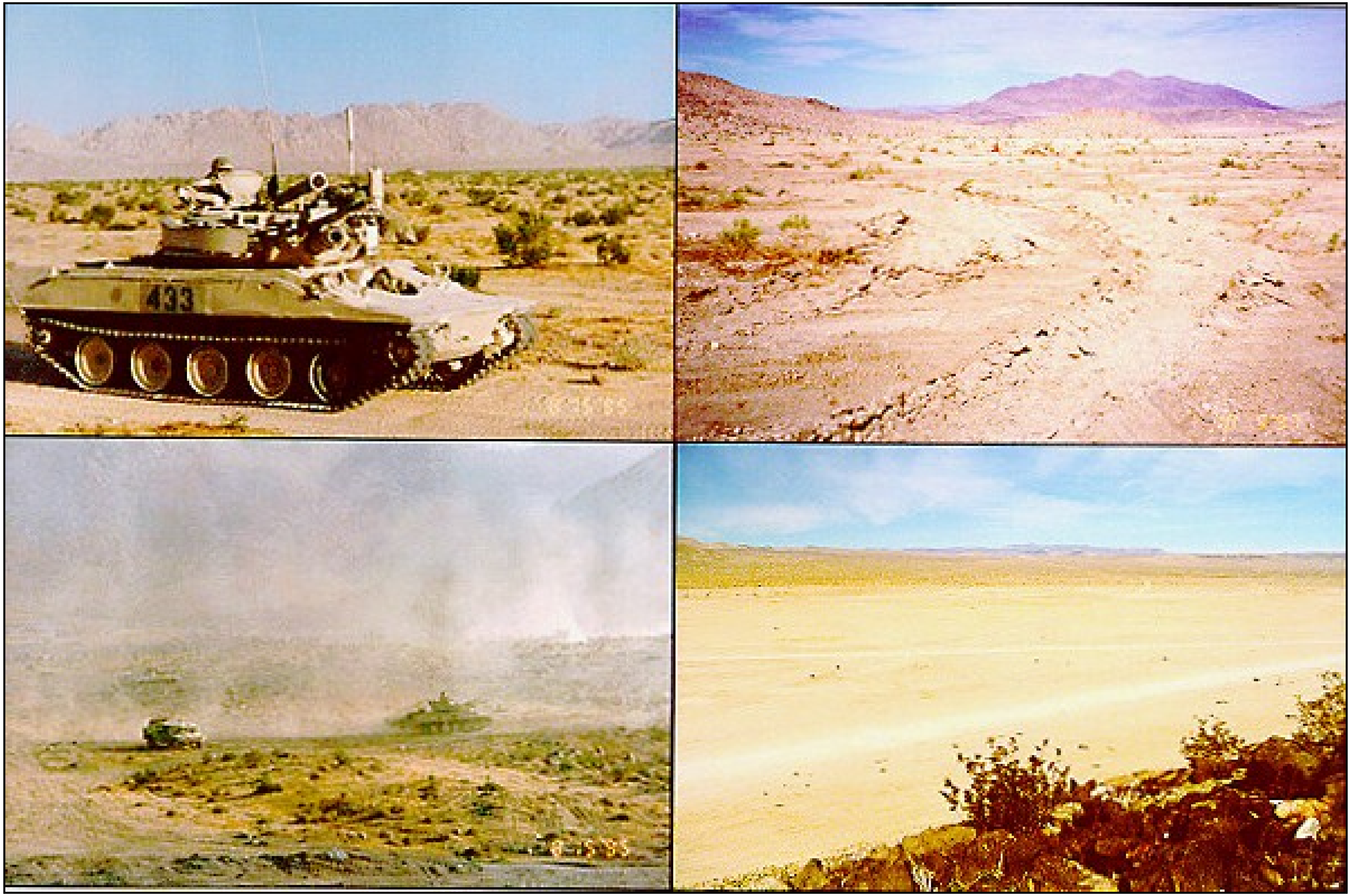
Strategic Environmental Research and Development Program (SERDP)
U.S. Environmental Protection Agency (EPA)
U.S. Department of Energy (DOE)
U.S. Department of Defense (DoD)
National Training Center at Fort Irwin, California (NTC)
Nevada Test Site (NTS)
Bechtel Nevada
Charis Corporation
California State University Dominguez Hills

The Four-year study was funded by SERDP.

Statement of Need

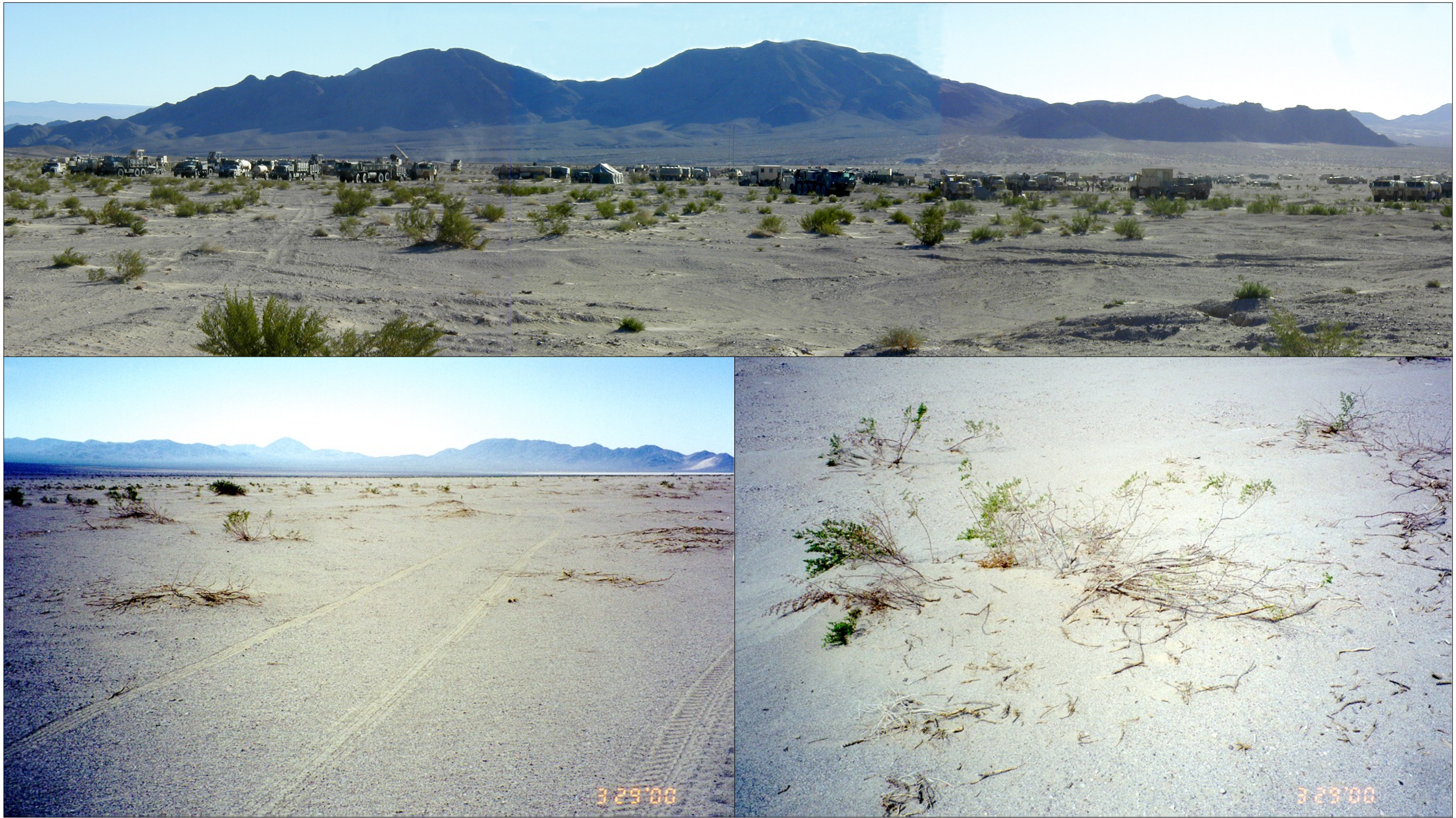
Measurements of vegetation and other related environmental parameters are essential for detecting changes in the landscape due to man-induced impacts. Collection of such data is usually labor-intensive, time-consuming, expensive, and has rather limited windows of opportunity in which to collect data. Innovative techniques are needed to provide such data.

Training Impacts



Training Impacts

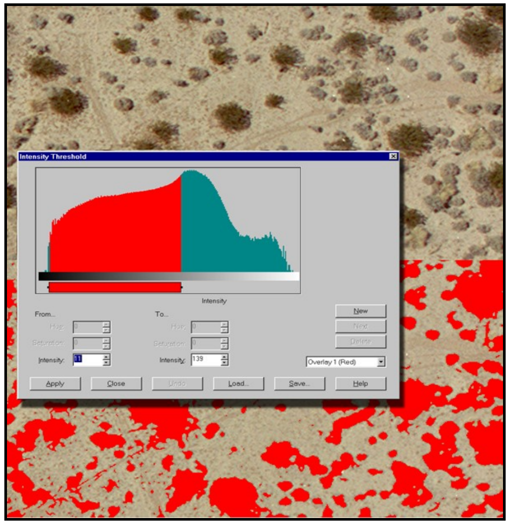
ENCAMPMENTS


3 29 '00
3 29 '00

Goal

Develop cost-effective techniques for measuring vegetation and other objects from digital images

Image Capture

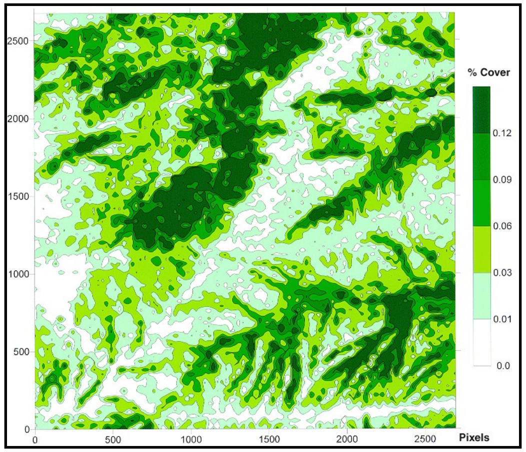

Intensity Threshold
Intensity
New
Next
Delete
Apply
Close
Undo
Load...
Save...
Help

From...
Hue: 0
Saturation: 0
Intensity: 11

To...
Hue: 0
Saturation: 0
Intensity: 139

Overlay 1 (Red)

Image Processing



Applications

Historical Background

NTS

Baneberry

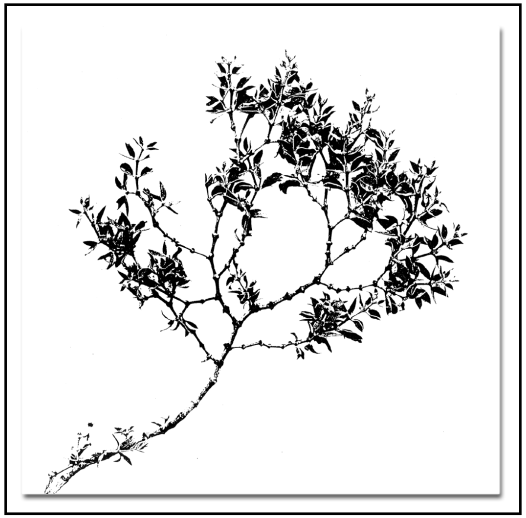
Nº 000042 EG&G 424

In 1974, Rhoads used an isodensitometer system to measure vegetation cover from aerial photographs because of restricted ground access in surface-contaminated radioactive areas of the NTS.

Historical Background

Yucca Mountain

Photocopy



In 1995, biologists and hydrologists of the Yucca Mountain Project needed to measure transpiration rates of plants in order to model movement of water and radioisotopes. Plant parts were photocopied and analyzed to measure

Historical Background

Fort Irwin

NTS

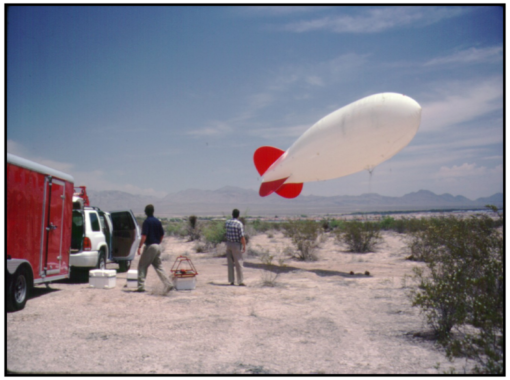
In 1999, research funded by SERDP was initiated to develop new diagnostic techniques to determine sustainable uses on DoD and DOE lands.

Methods

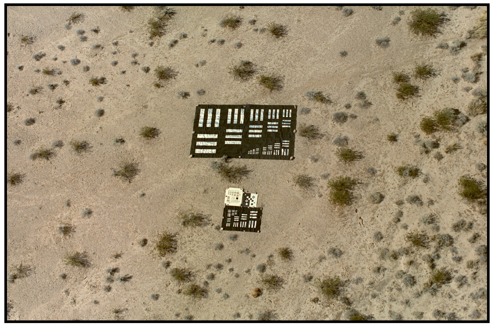
Image Capturing Techniques

Satellites

Airplanes

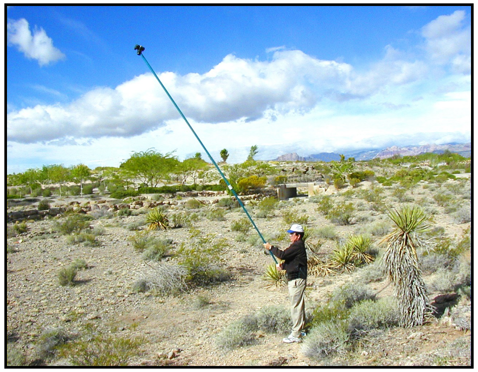


Blimps



Helicopters

Scanners



Hand-held Poles

Bechtel Nevada

Image Capture

Aerial Photography

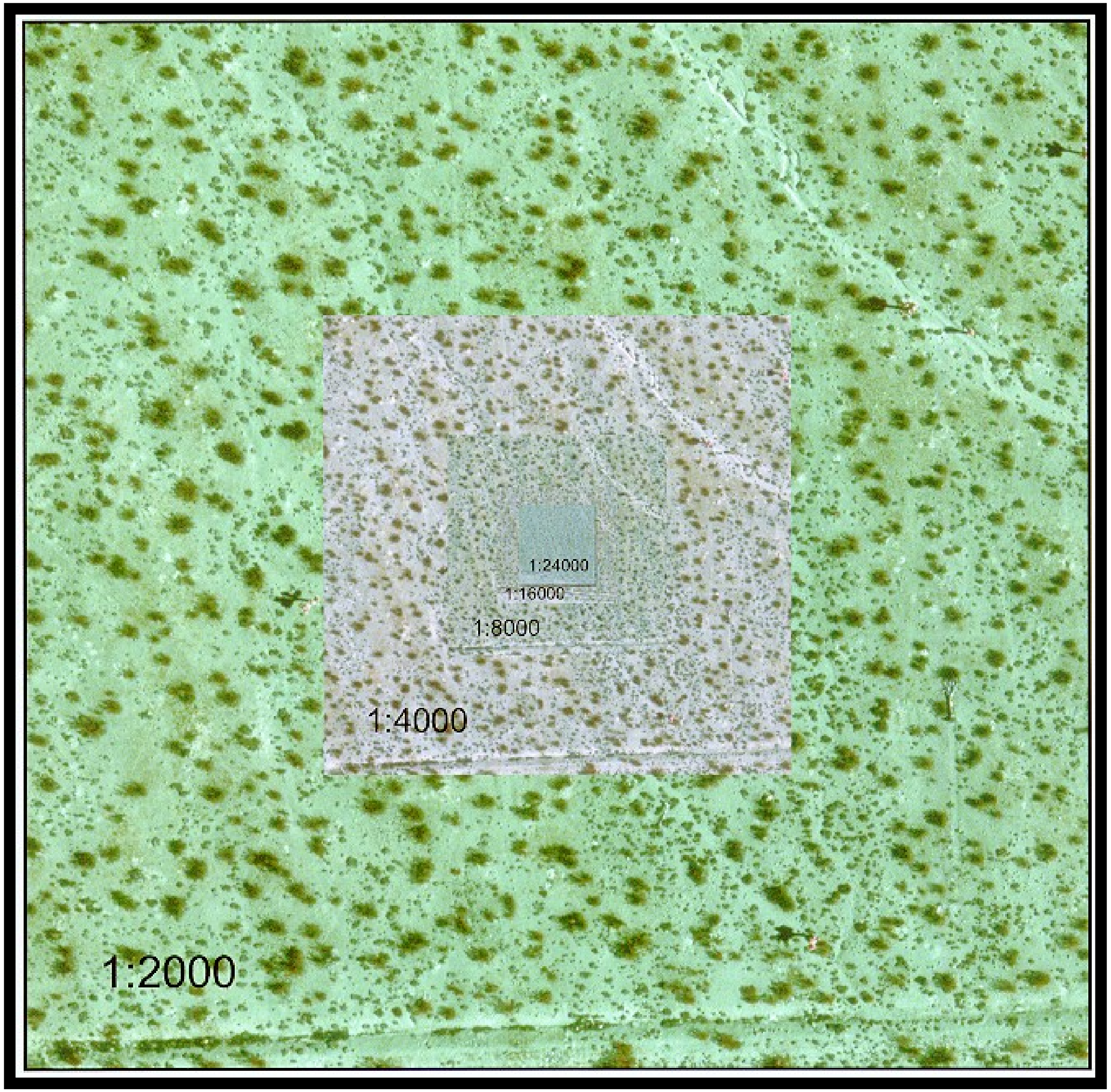

1:24000
1:16000
1:8000
1:4000
1:2000

Image Capture

Helicopter

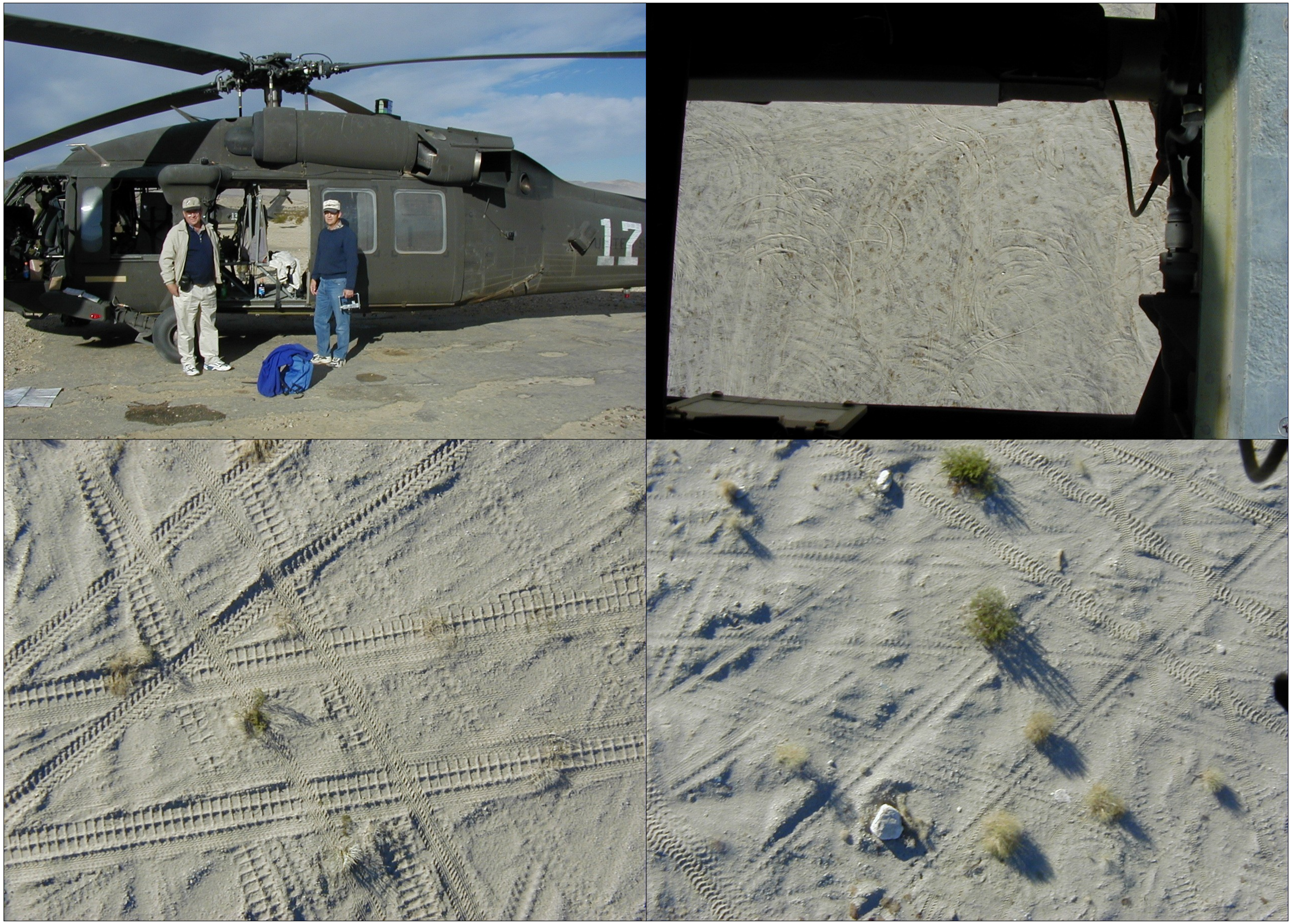


Image Processing

National Training Center at Fort Irwin
Change Detection using Satellite Imagery

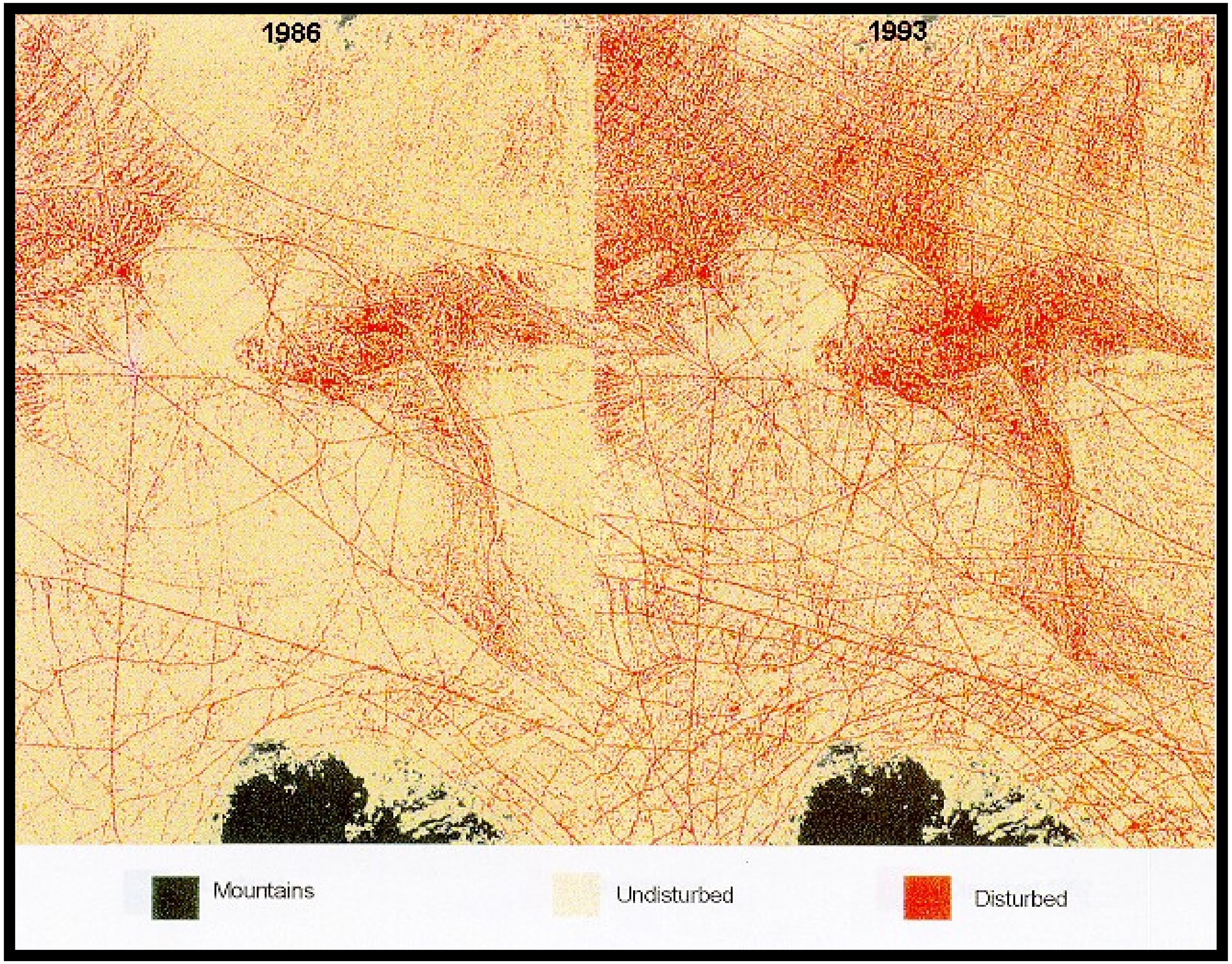

1986
1993
Mountains
Undisturbed
Disturbed

Image Processing

National Training Center at Fort Irwin
Aerial Photography, Satellite Imagery, and Rapid Assessment of Vegetative Structures (RAVS)

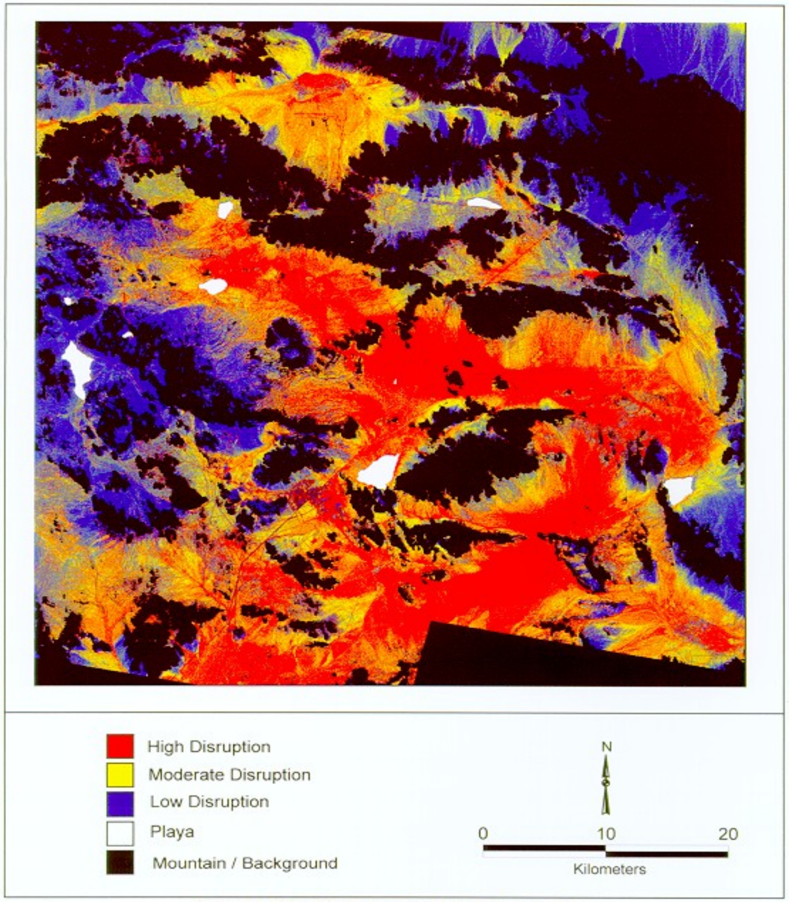

🟥 High Disruption
🟨 Moderate Disruption
🟪 Low Disruption
☐ Playa
⬛ Mountain / Background
N
0
10
20
Kilometers

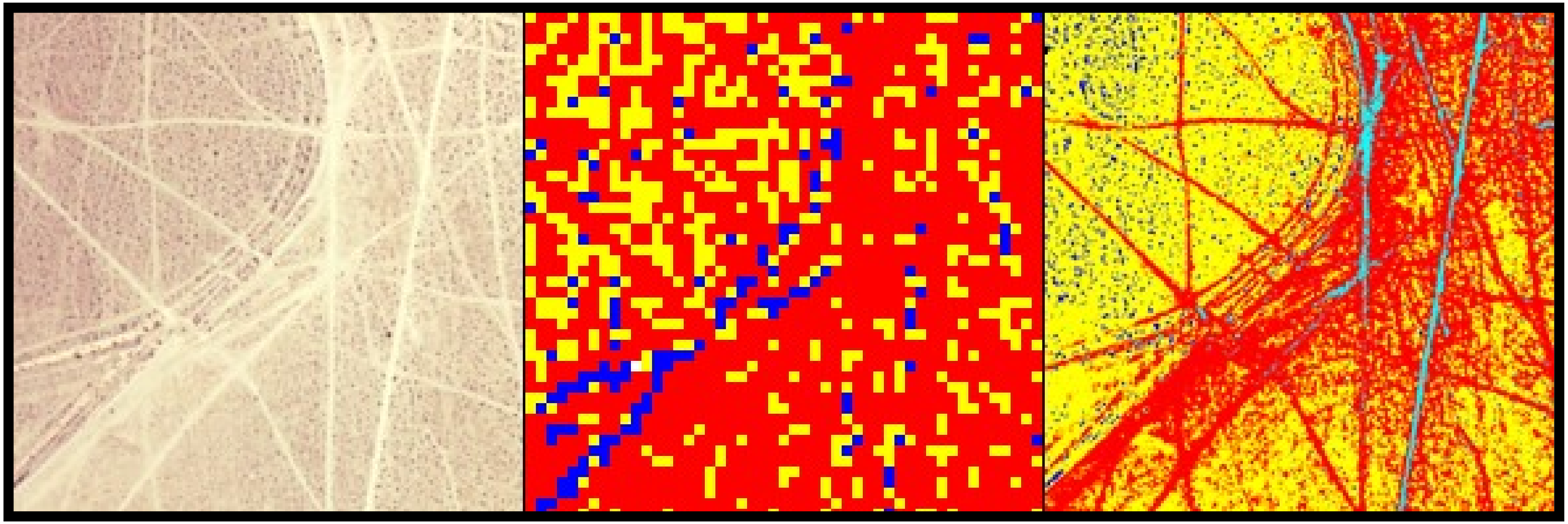
Figure II.8 Three Class Disruption Map - Fort Irwin, 1996

Image Processing

National Training Center at Fort Irwin
Change Detection using Satellite Imagery

Image Processing

National Training Center at Fort Irwin
Aerial Photography, Satellite Imagery, and RAVS

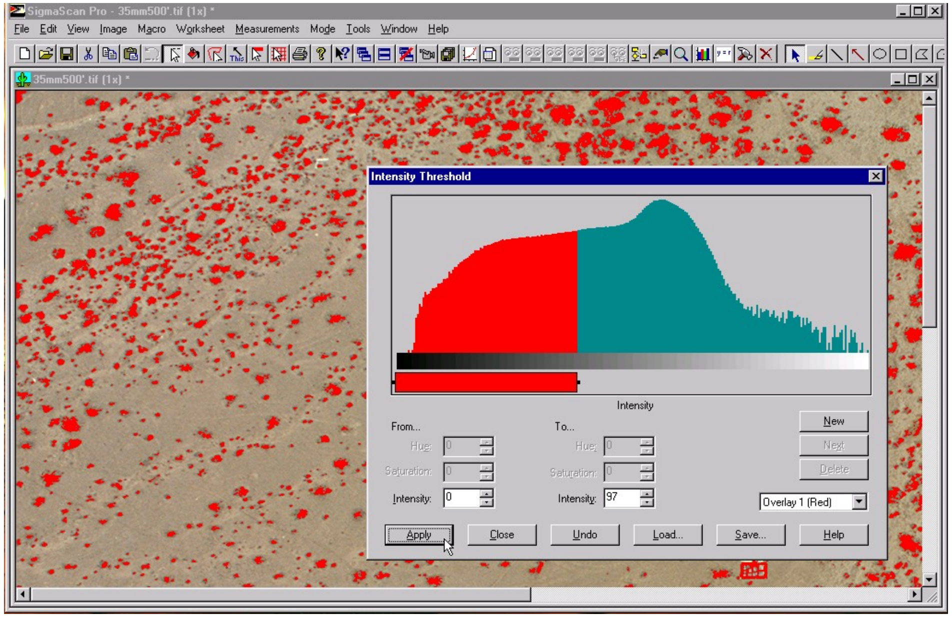


Aerial Photo **Satellite Image** **RAVS**

64 grids (each 500-meter X 500-meter) were evaluated

Image-Processing Techniques

(RAVS)


File
Edit
View
Image
Macro
Worksheet
Measurements
Mode
Tools
Window
Help
Intensity
New
Next
Delete
Apply
Close
Undo
Load...
Save...
Help

SigmaScan Pro - 35mm500'.tif (1x) *

35mm500'.tif (1x) *

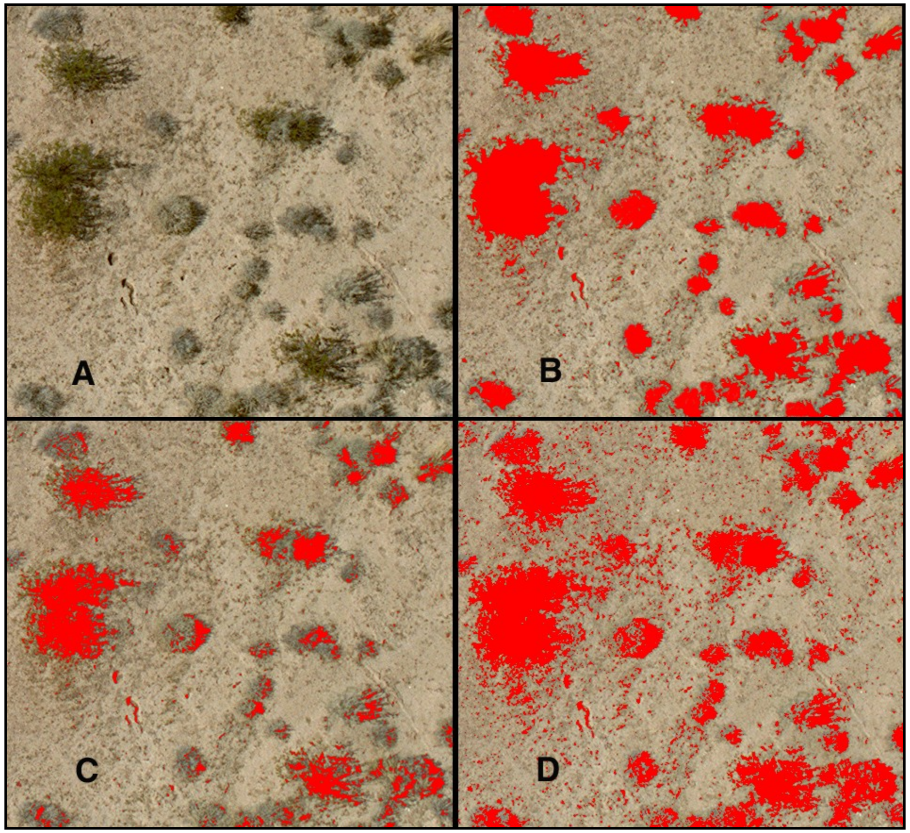
Intensity Threshold

From...
Hue: 0
Saturation: 0
Intensity: 0

To...
Hue: 0
Saturation: 0
Intensity: 97

Overlay 1 (Red)

Histogram Analyses



Proper Thresholding

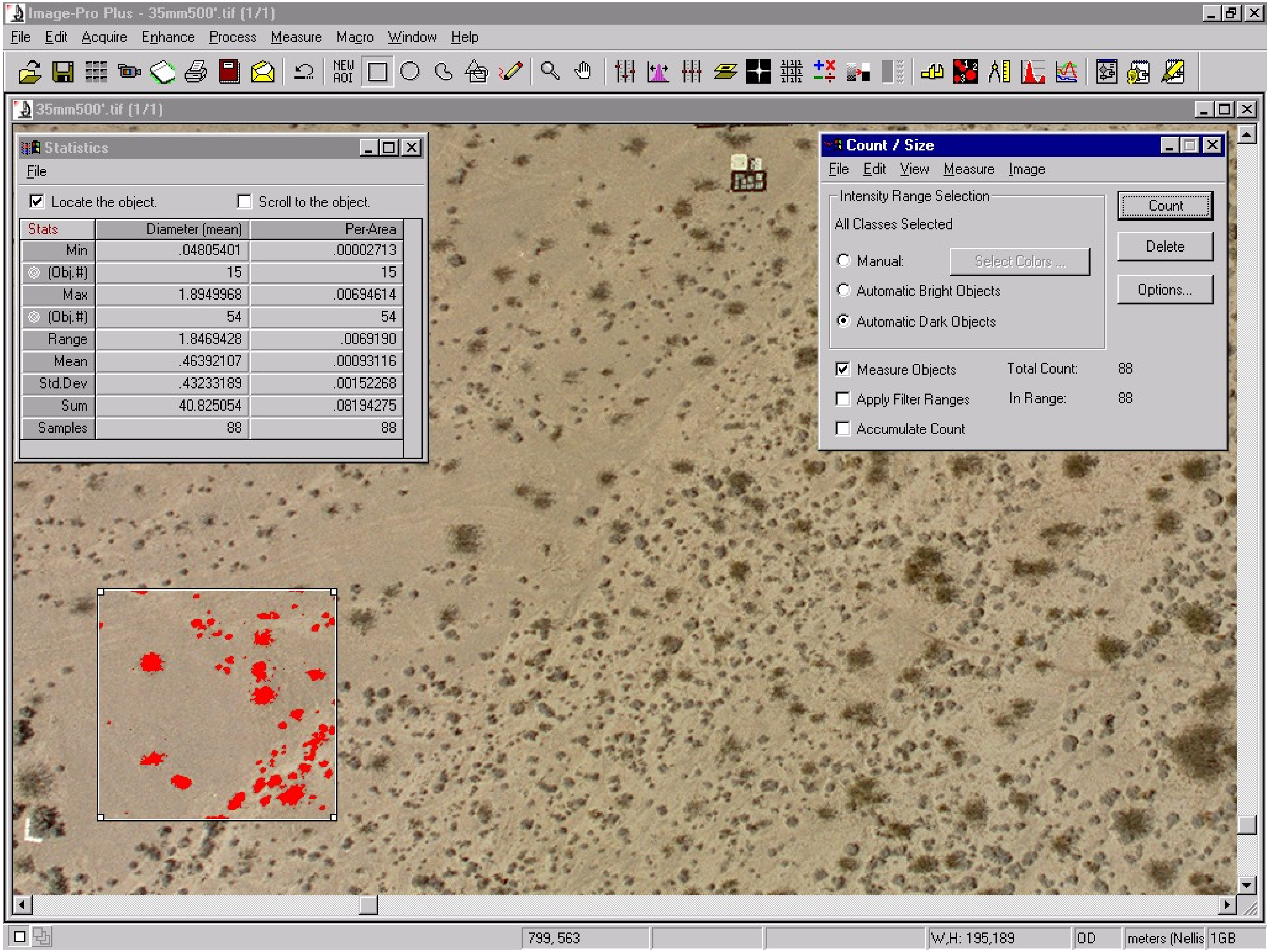


Image-Pro Plus - 35mm500'.tif (1/1)
File Edit Acquire Enhance Process Measure Macro Window Help
NEW AOI
35mm500'.tif (1/1)
Statistics
File
Count / Size
File Edit View Measure Image
Count
Delete
Options...
Select Colors ...

☑ Locate the object. ☐ Scroll to the object.

Stats	Diameter (mean)	Per-Area
Min	.04805401	.00002713
(Obj.#)	15	15
Max	1.8949968	.00694614
(Obj.#)	54	54
Range	1.8469428	.0069190
Mean	.46392107	.00093116
Std.Dev	.43233189	.00152268
Sum	40.825054	.08194275
Samples	88	88

Intensity Range Selection

All Classes Selected

○ Manual:

○ Automatic Bright Objects

● Automatic Dark Objects

☑ Measure Objects

☐ Apply Filter Ranges

☐ Accumulate Count

Total Count: 88

In Range: 88

799, 563 | W,H: 195,189 | OD | meters (Nellis | 1GB

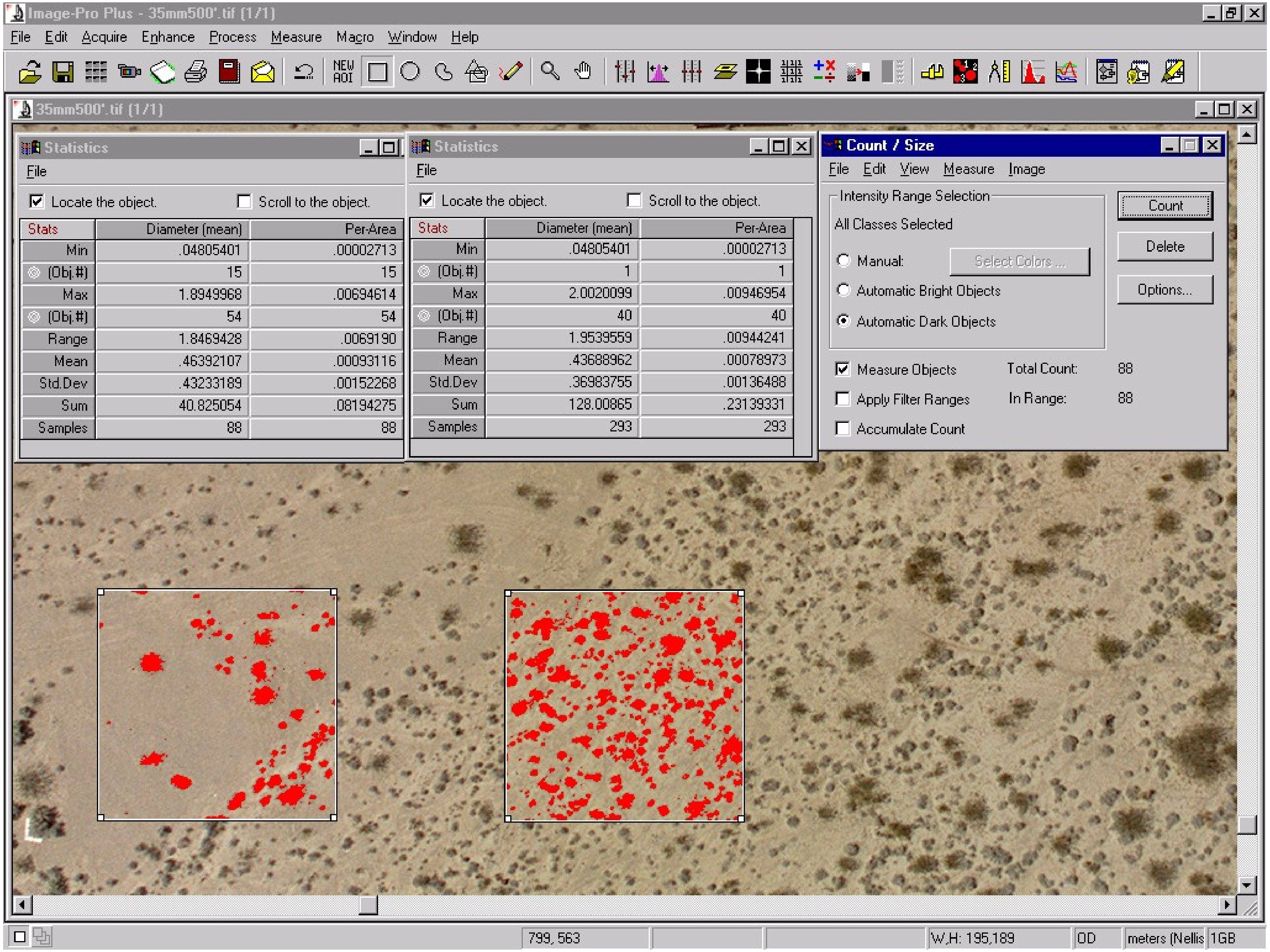


Image-Pro Plus - 35mm500'.tif (1/1)
File Edit Acquire Enhance Process Measure Macro Window Help
NEW AOI
35mm500'.tif (1/1)
Statistics
File
Count / Size
File Edit View Measure Image
Count
Delete
Options...
Select Colors ...

Statistics

☑ Locate the object. ☐ Scroll to the object.

Stats	Diameter (mean)	Per-Area
Min	.04805401	.00002713
(Obj.#)	15	15
Max	1.8949968	.00694614
(Obj.#)	54	54
Range	1.8469428	.0069190
Mean	.46392107	.00093116
Std.Dev	.43233189	.00152268
Sum	40.825054	.08194275
Samples	88	88

Statistics

☑ Locate the object. ☐ Scroll to the object.

Stats	Diameter (mean)	Per-Area
Min	.04805401	.00002713
(Obj.#)	1	1
Max	2.0020099	.00946954
(Obj.#)	40	40
Range	1.9539559	.00944241
Mean	.43688962	.00078973
Std.Dev	.36983755	.00136488
Sum	128.00865	.23139331
Samples	293	293

Count / Size

Intensity Range Selection

All Classes Selected

○ Manual:

○ Automatic Bright Objects

● Automatic Dark Objects

☑ Measure Objects

☐ Apply Filter Ranges

☐ Accumulate Count

Total Count: 88

In Range: 88

799, 563 | W,H: 195,189 | OD | meters (Nellis | 1GB

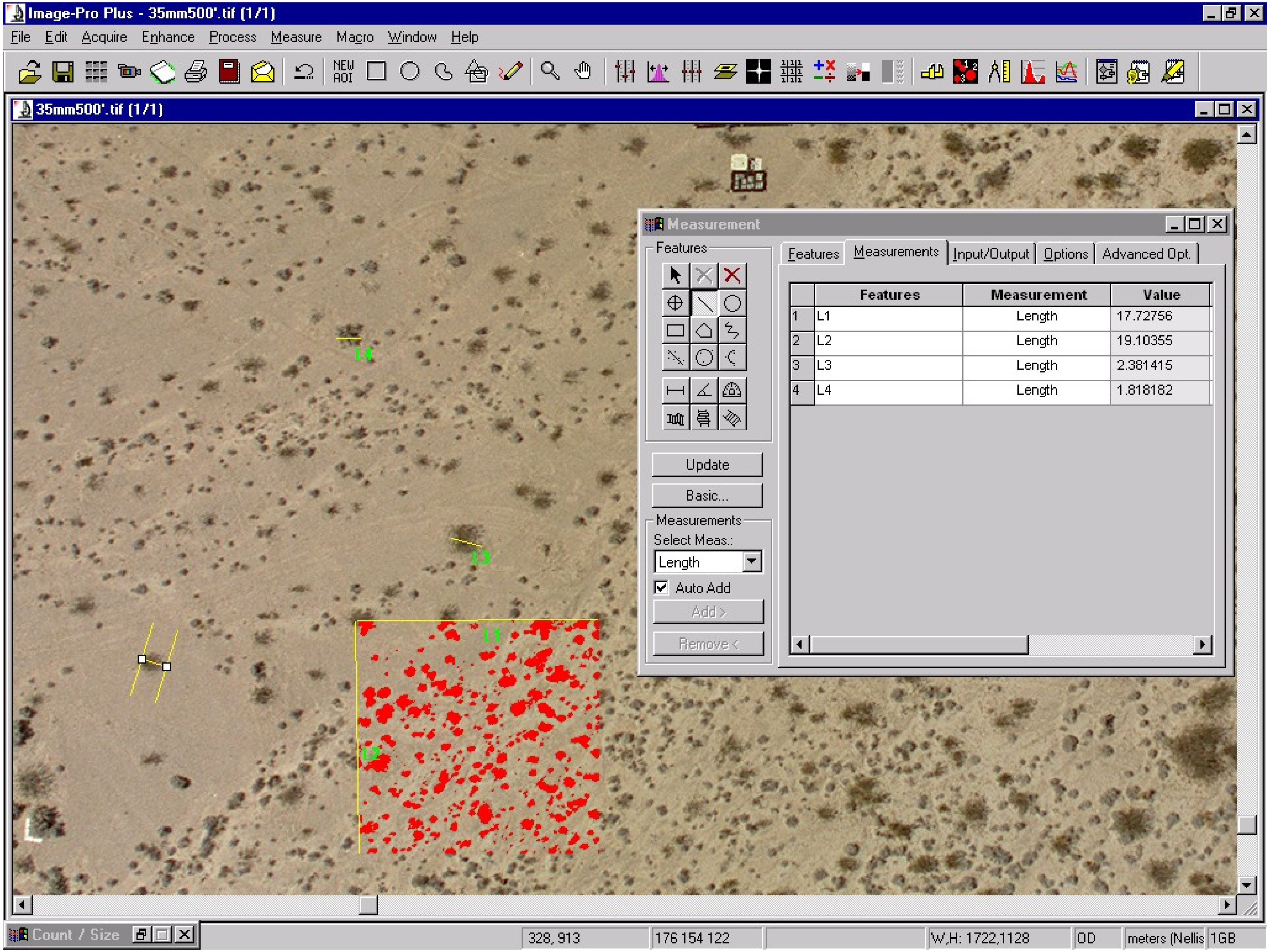


Image-Pro Plus - 35mm500'.tif (1/1)
File Edit Acquire Enhance Process Measure Macro Window Help
35mm500'.tif (1/1)
Measurement
Features
Features Measurements Input/Output Options Advanced Opt.
Update
Basic...
Measurements
Add >
Remove <
L1
L2
L3
L4
Count / Size

	Features	Measurement	Value
1	L1	Length	17.72756
2	L2	Length	19.10355
3	L3	Length	2.381415
4	L4	Length	1.818182

Select Meas.: Length

☑ Auto Add

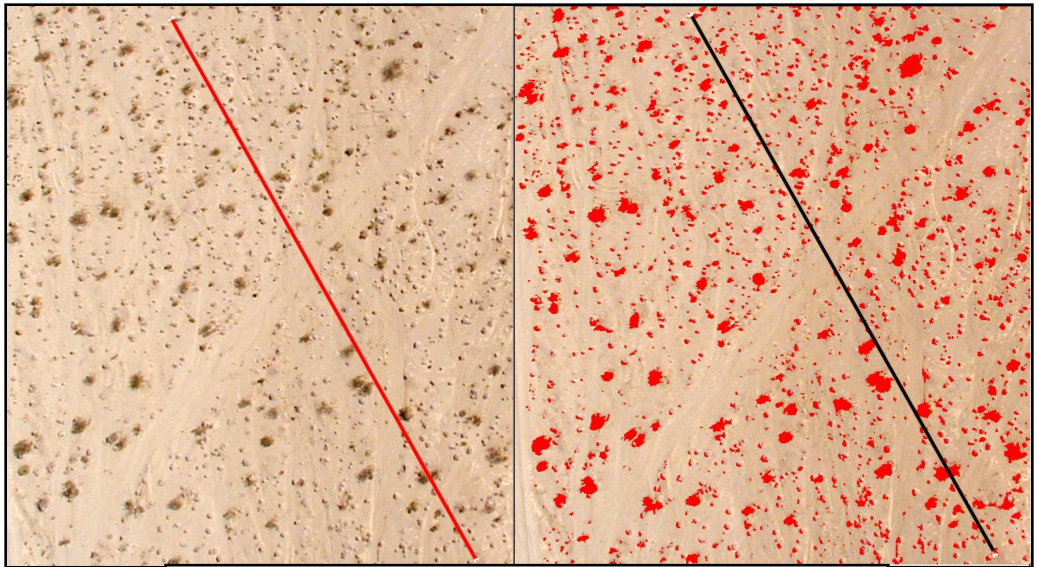
328, 913 | 176 154 122 | W,H: 1722,1128 | OD | meters (Nellis | 1GB

Results

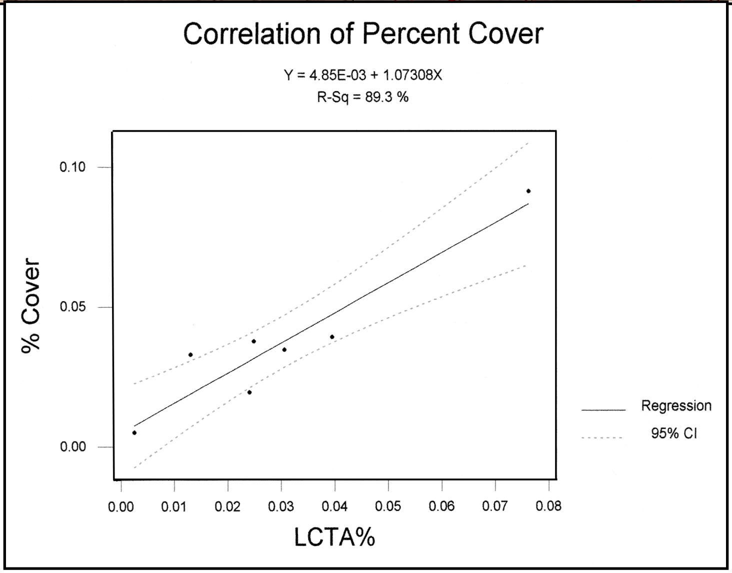
Image Processing - at Fort Irwin
Land Condition and Trend Analysis (LCTA) vs. RAVS

LCTA

ConventionalLine Intercept



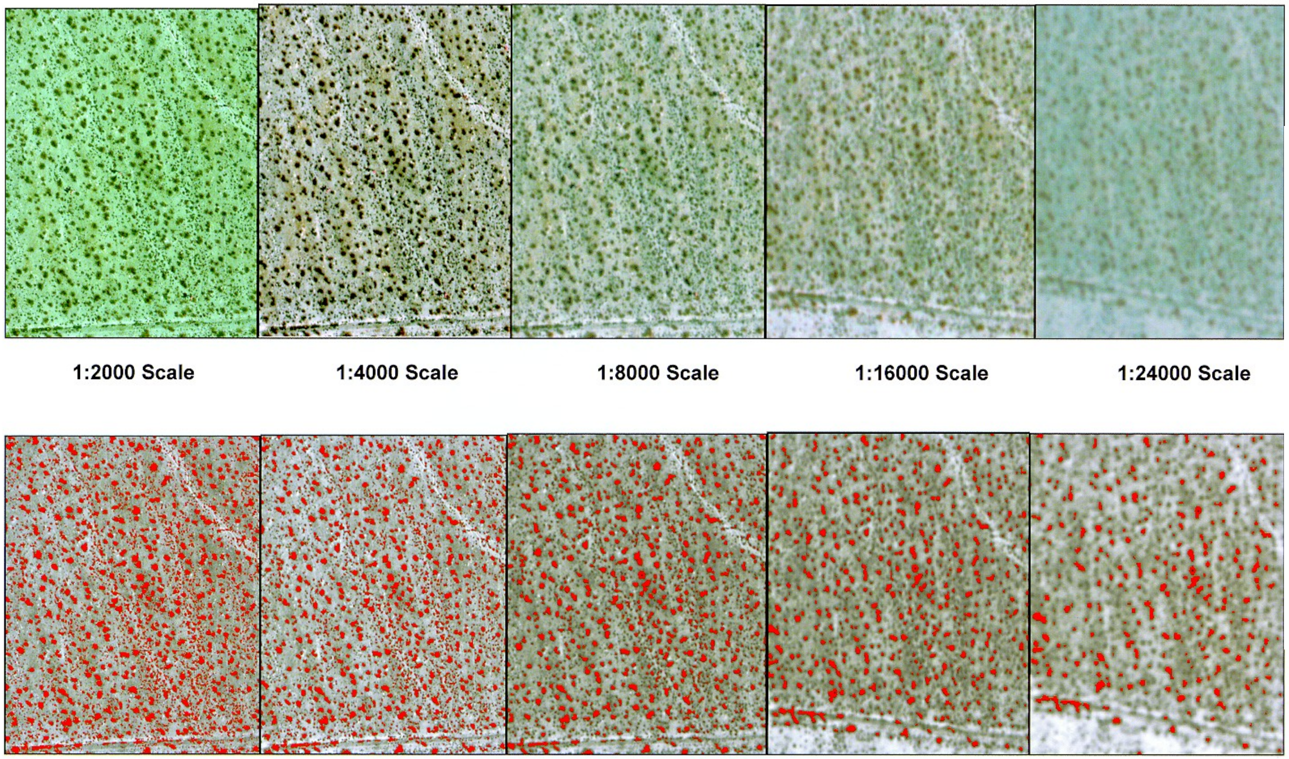
RAVS



Results

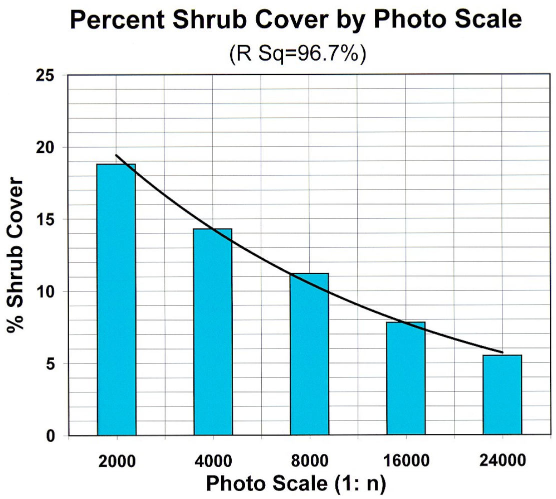
Image Processing - % Cover vs. Scale

Estimates Of Percent Shrub Cover Using Aerial Photographs Of Different Scales



1:2000 Scale | 1:4000 Scale | 1:8000 Scale | 1:16000 Scale | 1:24000 Scale

18.8% Cover | 14.3% Cover | 11.2% Cover | 7.8% Cover | 5.5% Cover

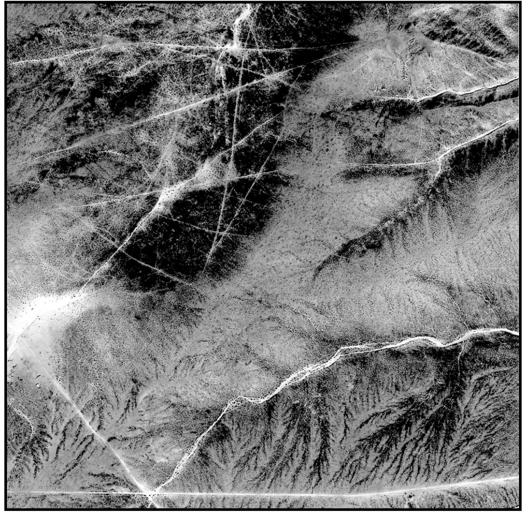


Results

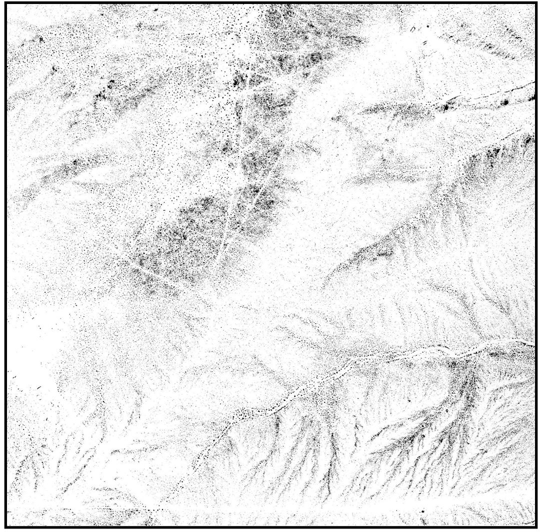
Image Processing at Twenty Nine Palms- IKONOS 1m

IKONOS

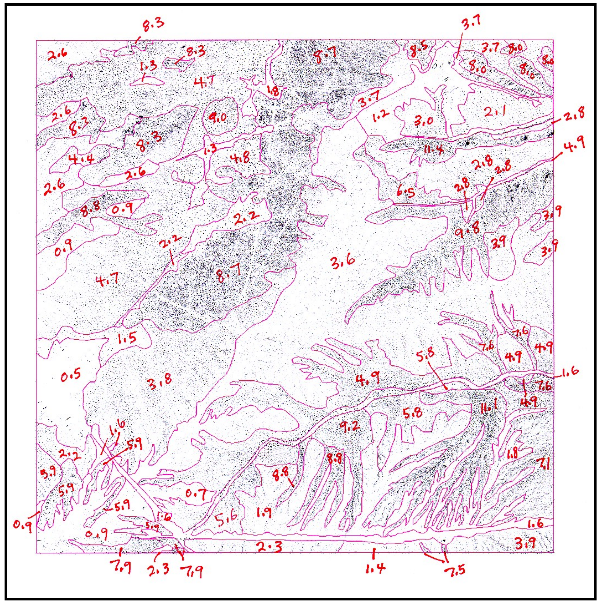
1 m



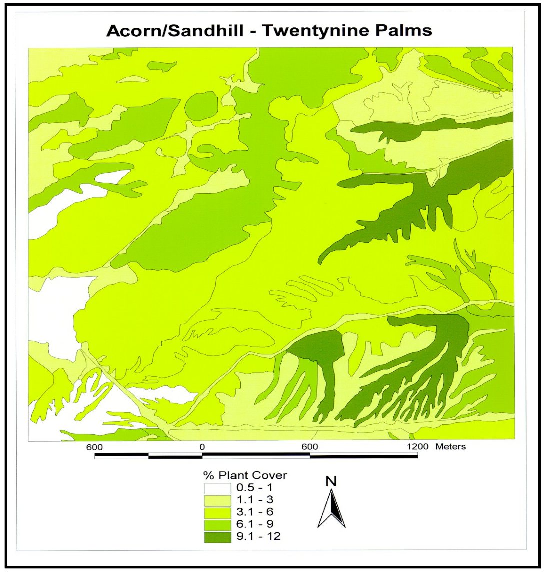
Shrub Silhouette



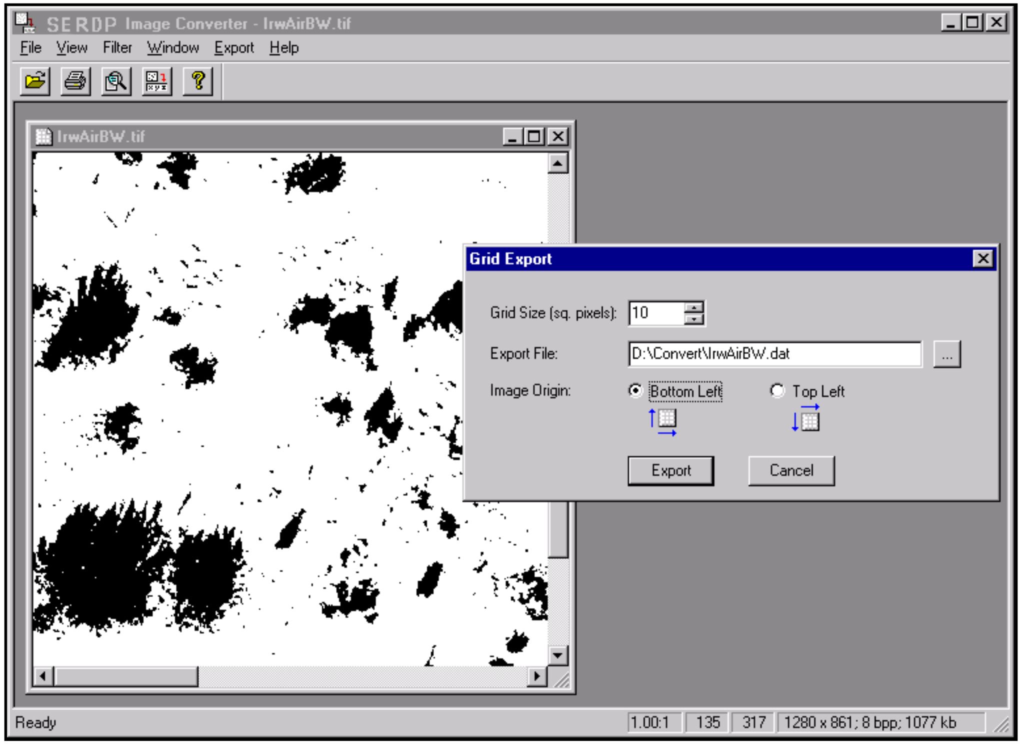
Hand-drawn map



Geographic Information Systems (GIS) Map


Acorn/Sandhill - Twentynine Palms
600
0
600
1200 Meters
% Plant Cover
0.5 - 1
1.1 - 3
3.1 - 6
6.1 - 9
9.1 - 12
N

Results - Software Development


SERDP Image Converter - IrwAirBW.tif
File
View
Filter
Window
Export
Help
IrwAirBW.tif
Grid Export
Export
Cancel

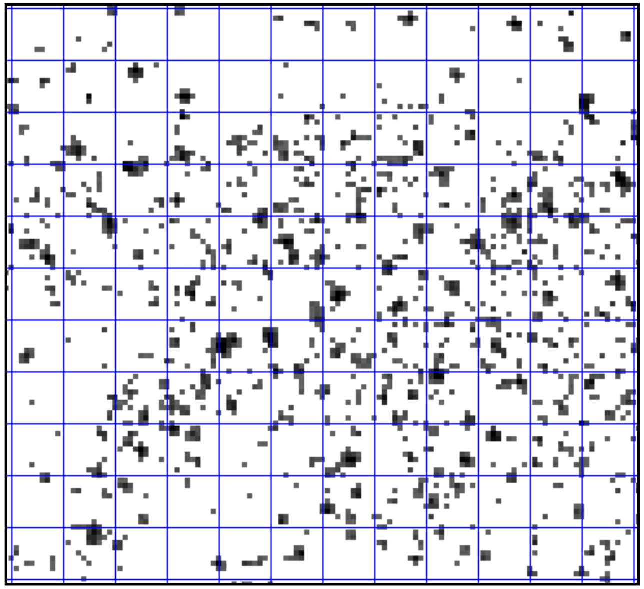
Grid Size (sq. pixels): 10

Export File: D:\Convert\IrwAirBW.dat

Image Origin: ● Bottom Left ○ Top Left

Ready 1.00:1 135 317 1280 x 861; 8 bpp; 1077 kb

SERDP Image Converter Software

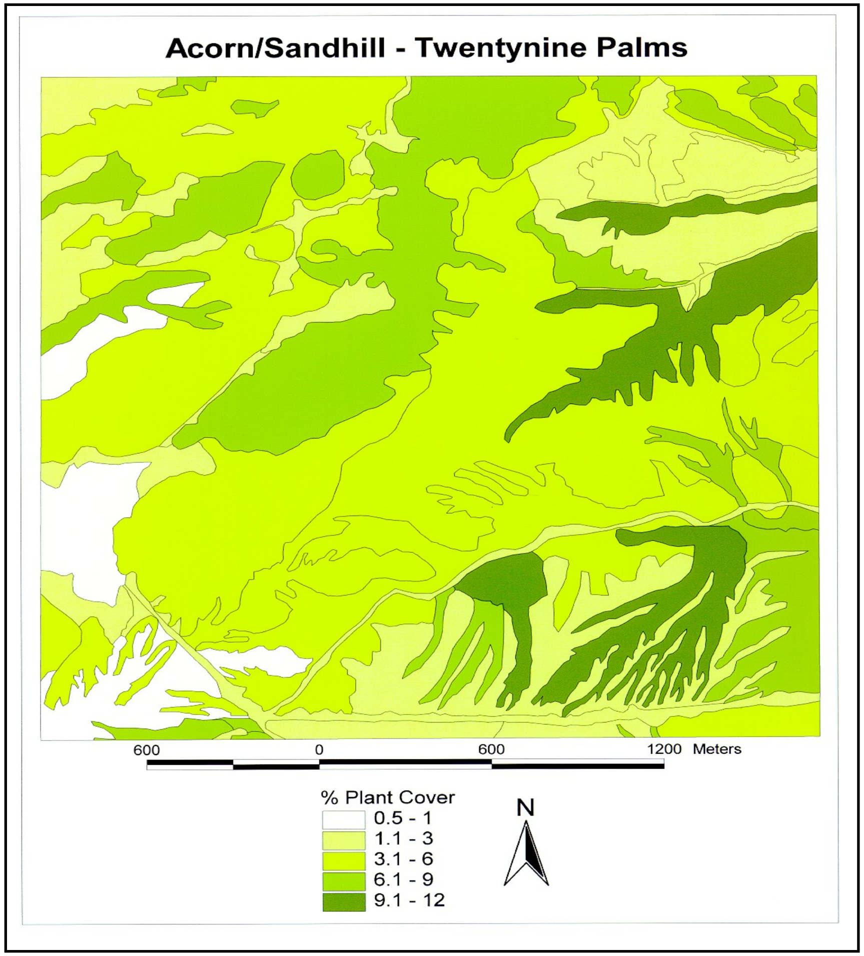


Surfer 7 File

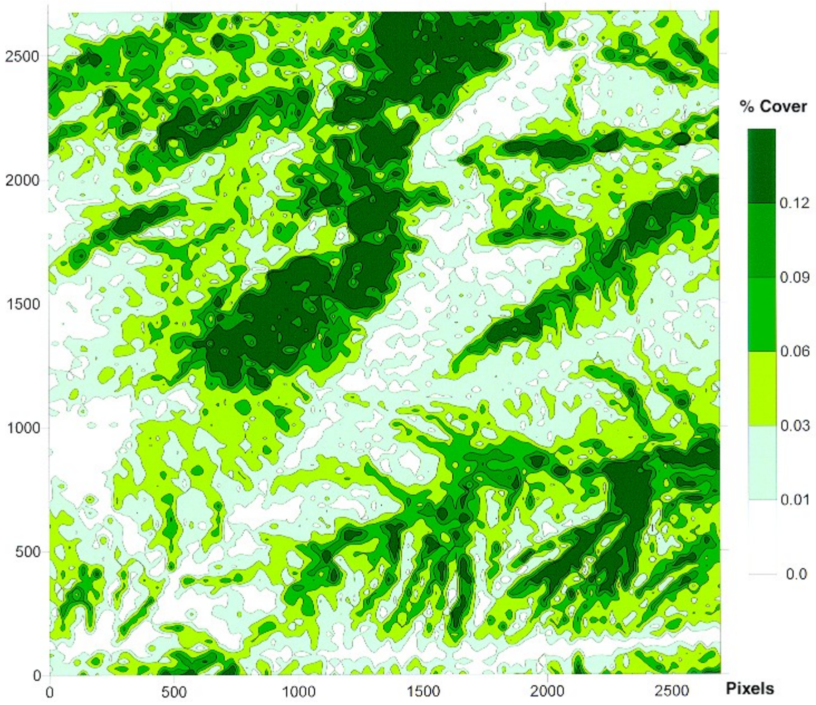
X	Y	Z
000	00	0.0
000	10	70.
	02	12

Results - GIS Coverages

Image Processing - IKONOS 1m Resolution Image


Acorn/Sandhill - Twentynine Palms
600
0
600
1200 Meters
% Plant Cover
0.5 - 1
1.1 - 3
3.1 - 6
6.1 - 9
9.1 - 12
N

Hand-digitized GIS Map

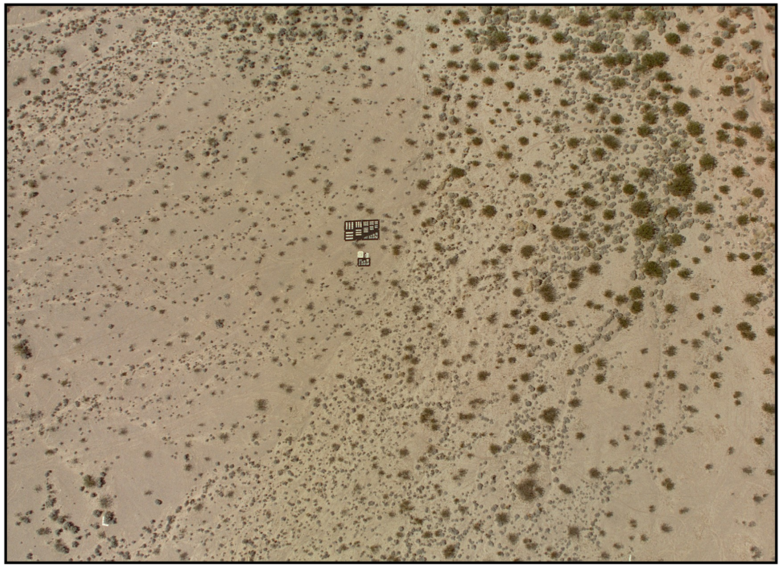

2500
2000
1500
1000
500
0
0
500
1000
1500
2000
2500
Pixels
% Cover
0.12
0.09
0.06
0.03
0.01
0.0

Automated Map

Results

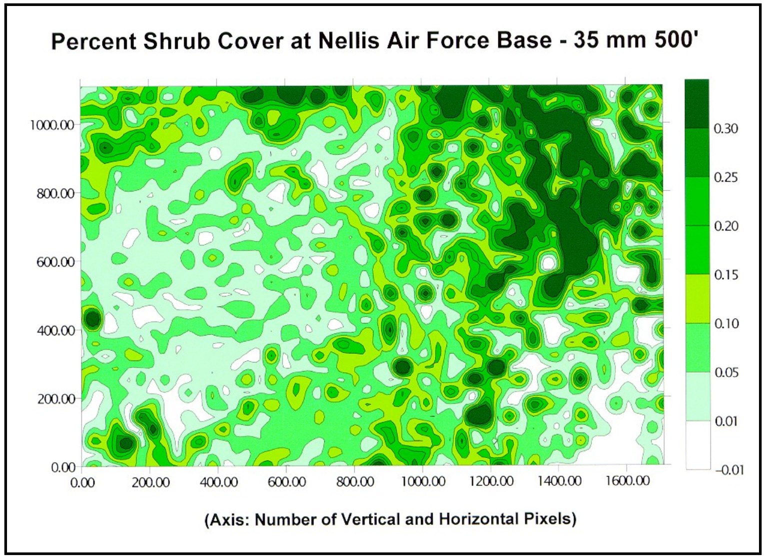
Image Processing - Surfer at Nellis Air Force Base

User can select the best scale to communicate site conditions



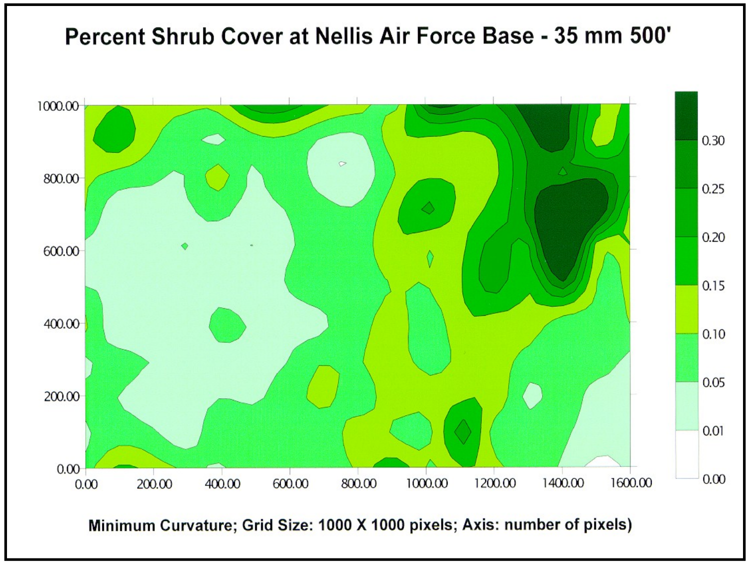
High Resolution

Low Resolution



Percent Shrub Cover at Nellis Air Force Base - 35 mm 500'

(Axis: Number of Vertical and Horizontal Pixels)

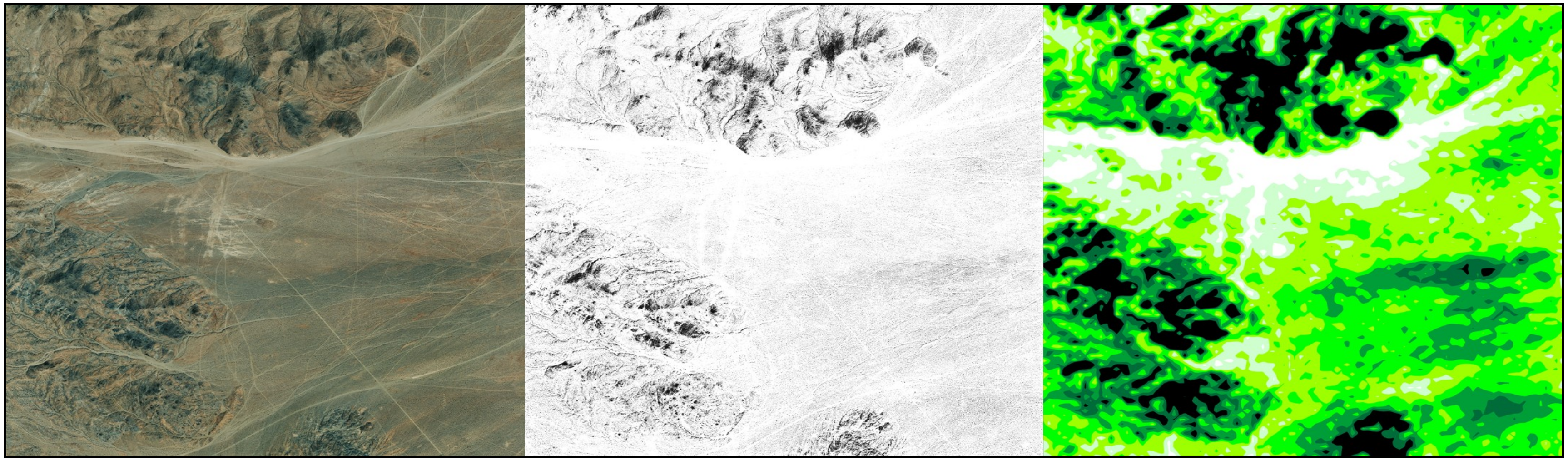


Percent Shrub Cover at Nellis Air Force Base - 35 mm 500'

Minimum Curvature; Grid Size: 1000 X 1000 pixels; Axis: number of pixels)

Results

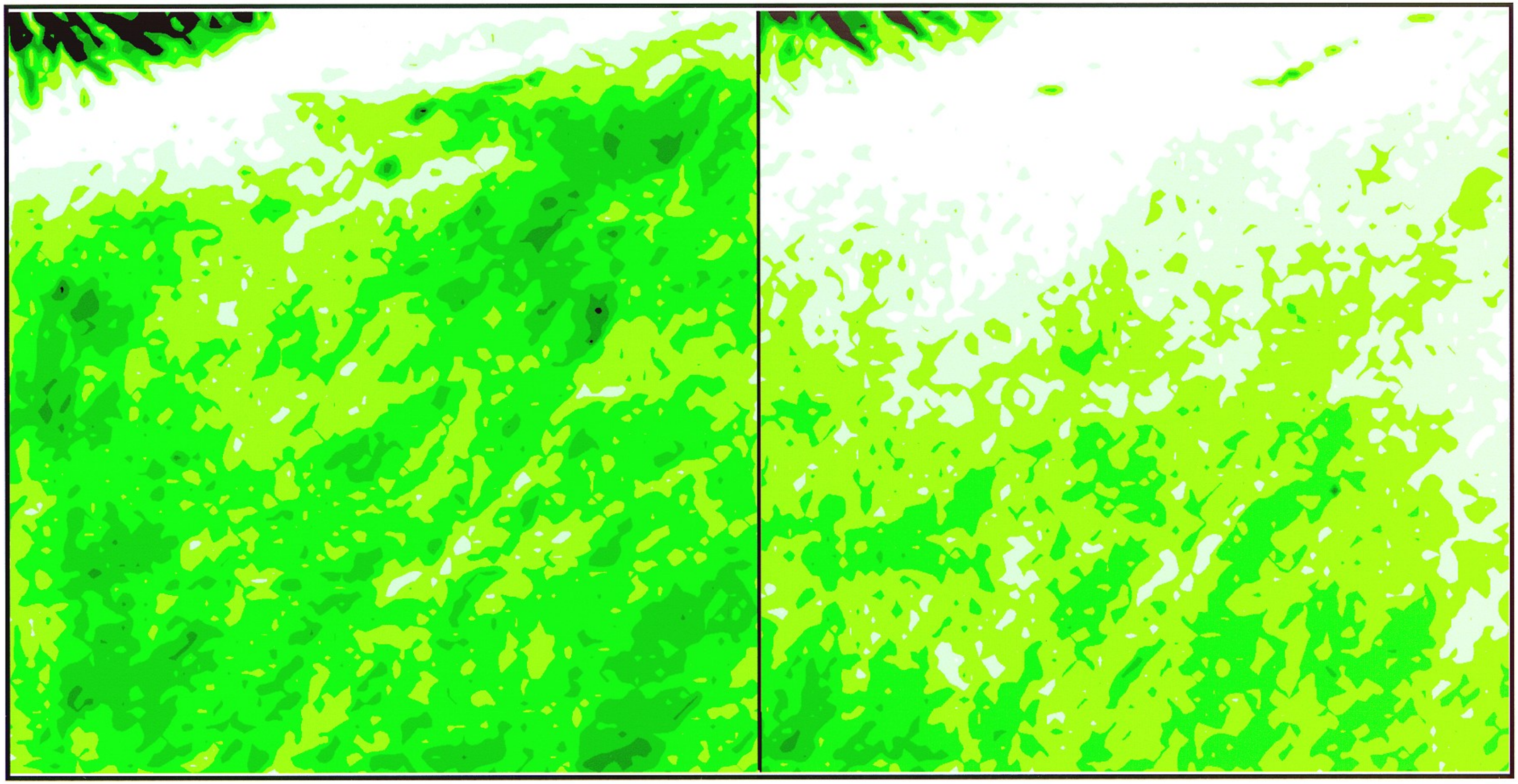
Image Processing - Multi-Resolution Seamless Image Database (MrSID) Fort Irwin



Color Photo → **SigmaScan Pro** → **Surfer**

Results

Image Processing - MrSID Fort Irwin



Percent shrub cover in increasing intervals of green from 0% (white), 1, 3, 6, 10, 15, to >21% (black)

Left image from photo taken in 1996. Right image from photo taken in 1999.

Applications

Diagnostic Techniques - Other Applications

- **Shrub-size class measurements**
- **Soil particle-size measurements**
- **Seed-sizes measurements**
- **Foliar density measurements**

Applications

Shrub-Size Class Measurements

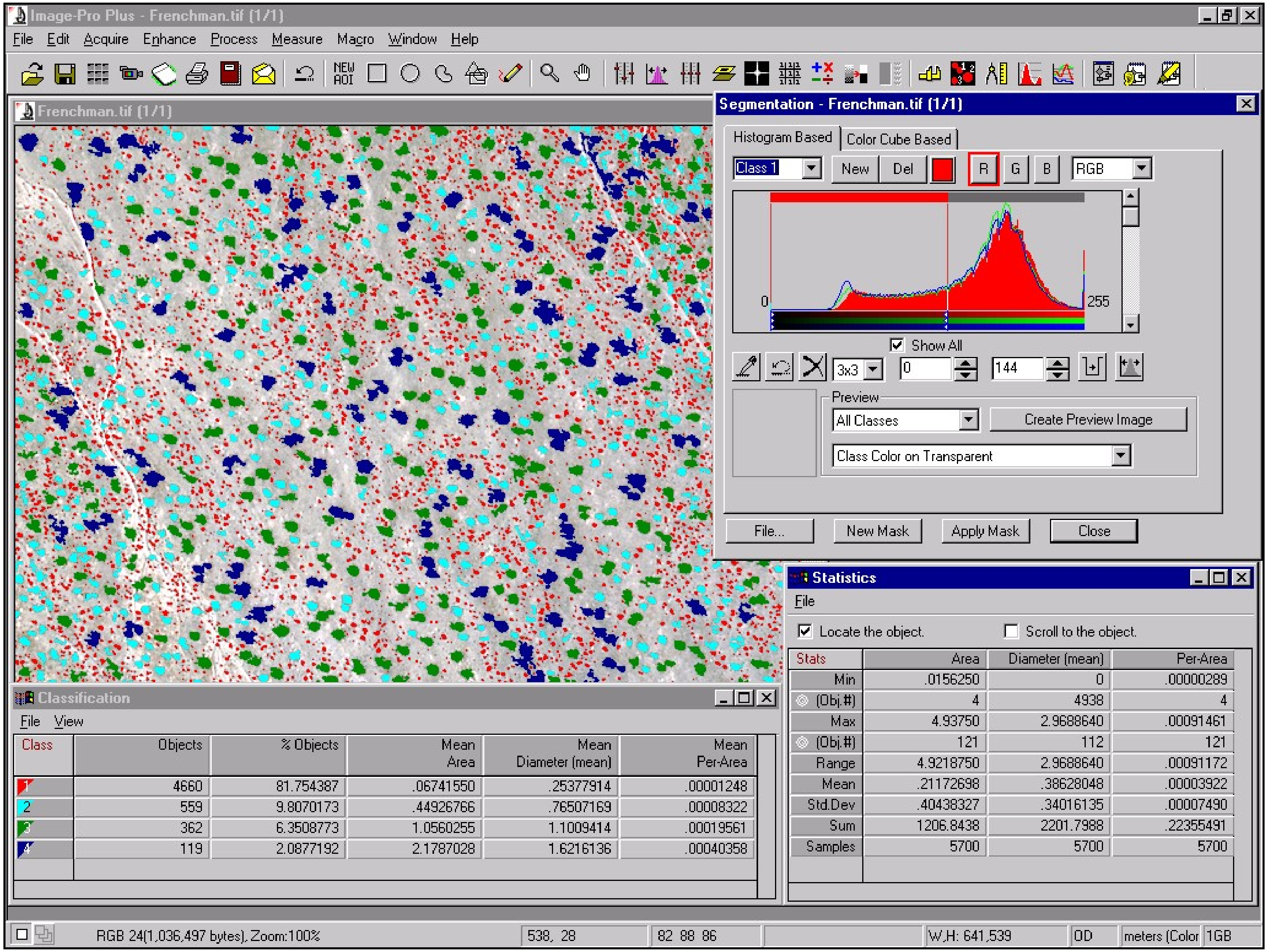


Image-Pro Plus - Frenchman.tif (1/1)
File Edit Acquire Enhance Process Measure Macro Window Help
Frenchman.tif (1/1)
Segmentation - Frenchman.tif (1/1)
Histogram Based
Color Cube Based
New
Del
R
G
B
0
255
Show All
Preview
Create Preview Image
File...
New Mask
Apply Mask
Close
Statistics
Classification
File View

Segmentation - Frenchman.tif (1/1): Class 1; RGB; ☑ Show All; 3x3; 0; 144; Preview: All Classes; Class Color on Transparent

Classification

Class	Objects	% Objects	Mean Area	Mean Diameter (mean)	Mean Per-Area
1	4660	81.754387	.06741550	.25377914	.00001248
2	559	9.8070173	.44926766	.76507169	.00008322
3	362	6.3508773	1.0560255	1.1009414	.00019561
4	119	2.0877192	2.1787028	1.6216136	.00040358

Statistics

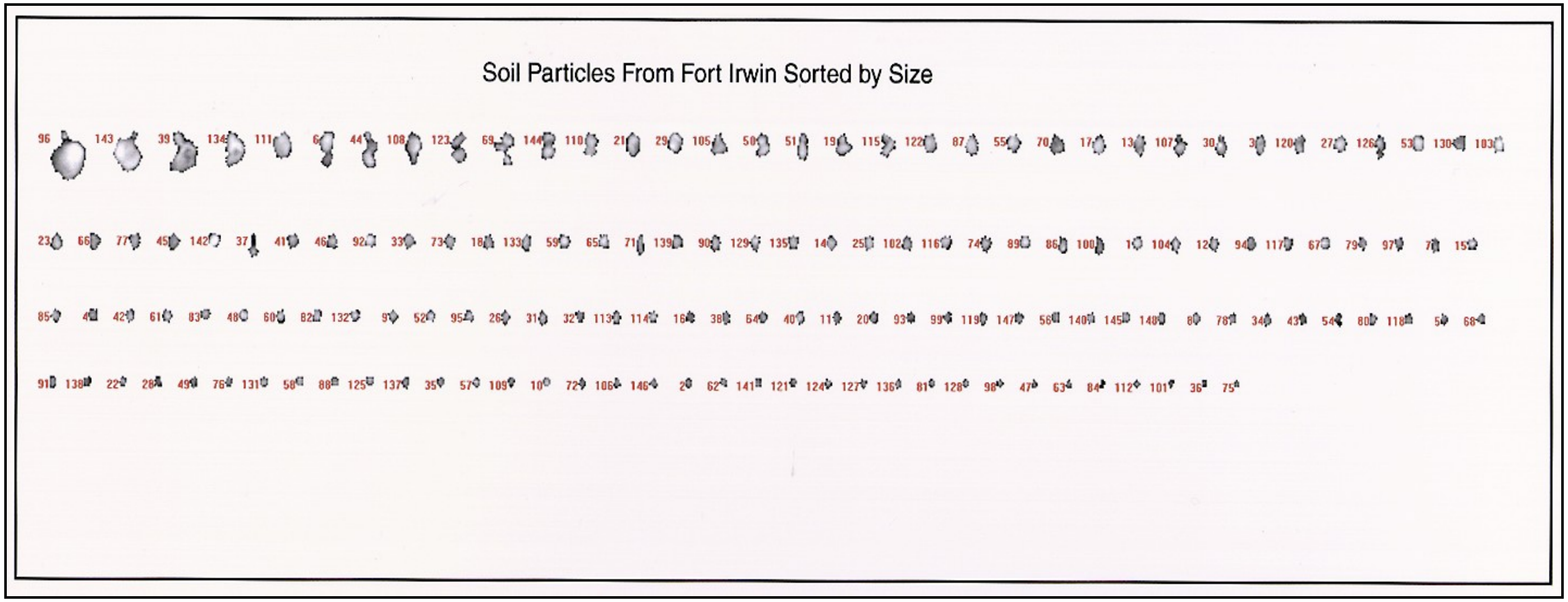
☑ Locate the object. ☐ Scroll to the object.

Stats	Area	Diameter (mean)	Per-Area
Min	.0156250	0	.00000289
(Obj.#)	4	4938	4
Max	4.93750	2.9688640	.00091461
(Obj.#)	121	112	121
Range	4.9218750	2.9688640	.00091172
Mean	.21172698	.38628048	.00003922
Std.Dev	.40438327	.34016135	.00007490
Sum	1206.8438	2201.7988	.22355491
Samples	5700	5700	5700

RGB 24(1,036,497 bytes), Zoom:100% | 538, 28 | 82 88 86 | W,H: 641,539 | OD | meters (Color | 1GB

Applications

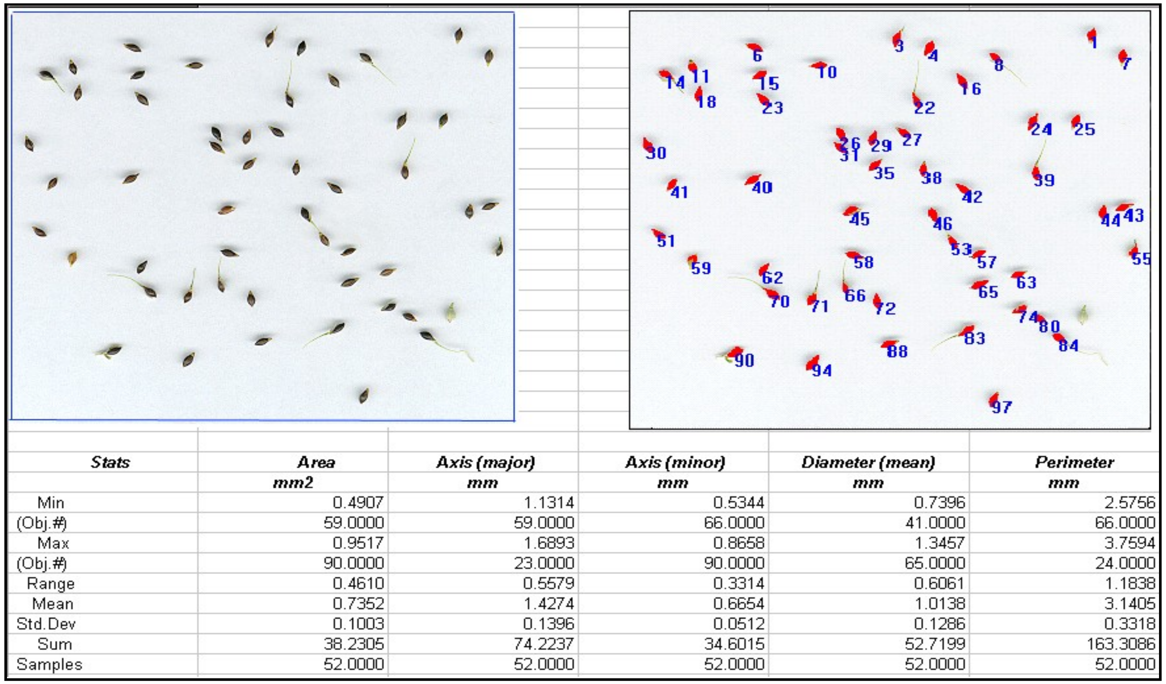
Soil Particle-Size Measurements


Soil Particles From Fort Irwin Sorted by Size

Sand, Silt, and Clay Particles Sorted by Size

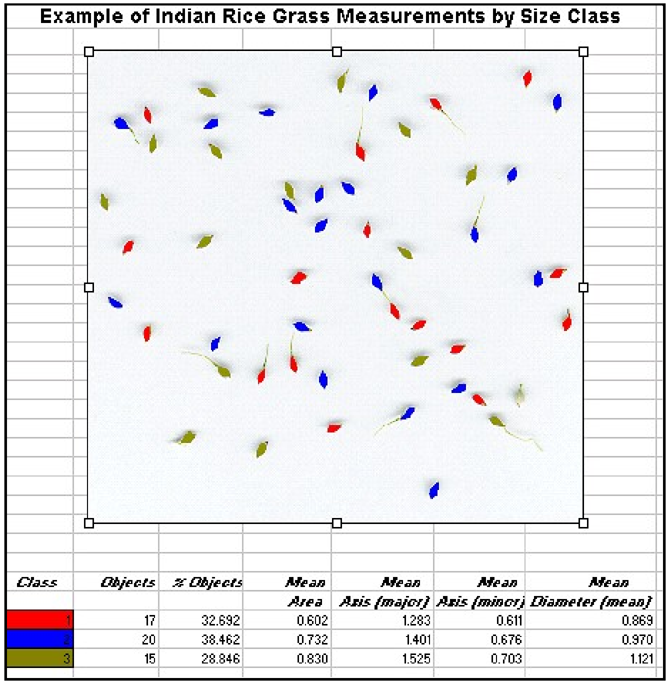
Applications

Seed-Size Measurements



1
3
4
6
7
8
10
11
14
15
16
18
22
23
24
25
26
27
29
30
31
35
38
39
40
41
42
43
44
45
46
51
53
55
57
58
59
62
63
65
66
70
71
72
74
80
83
84
88
90
94
97

Stats	Area	Axis (major)	Axis (minor)	Diameter (mean)	Perimeter
	mm2	mm	mm	mm	mm
Min	0.4907	1.1314	0.5344	0.7396	2.5756
(Obj.#)	59.0000	59.0000	66.0000	41.0000	66.0000
Max	0.9517	1.6893	0.8658	1.3457	3.7594
(Obj.#)	90.0000	23.0000	90.0000	65.0000	24.0000
Range	0.4610	0.5579	0.3314	0.6061	1.1838
Mean	0.7352	1.4274	0.6654	1.0138	3.1405
Std.Dev	0.1003	0.1396	0.0512	0.1286	0.3318
Sum	38.2305	74.2237	34.6015	52.7199	163.3086
Samples	52.0000	52.0000	52.0000	52.0000	52.0000



Example of Indian Rice Grass Measurements by Size Class

Class	Objects	% Objects	Mean Area	Mean Axis (major)	Mean Axis (minor)	Mean Diameter (mean)
🟥 1	17	32.692	0.602	1.283	0.611	0.869
🟦 2	20	38.462	0.732	1.401	0.676	0.970
▨ 3	15	28.846	0.830	1.525	0.703	1.121

Indian Rice Grass Seed Measurements

Applications

Foliar Density Measurements for Wind Erosion Models

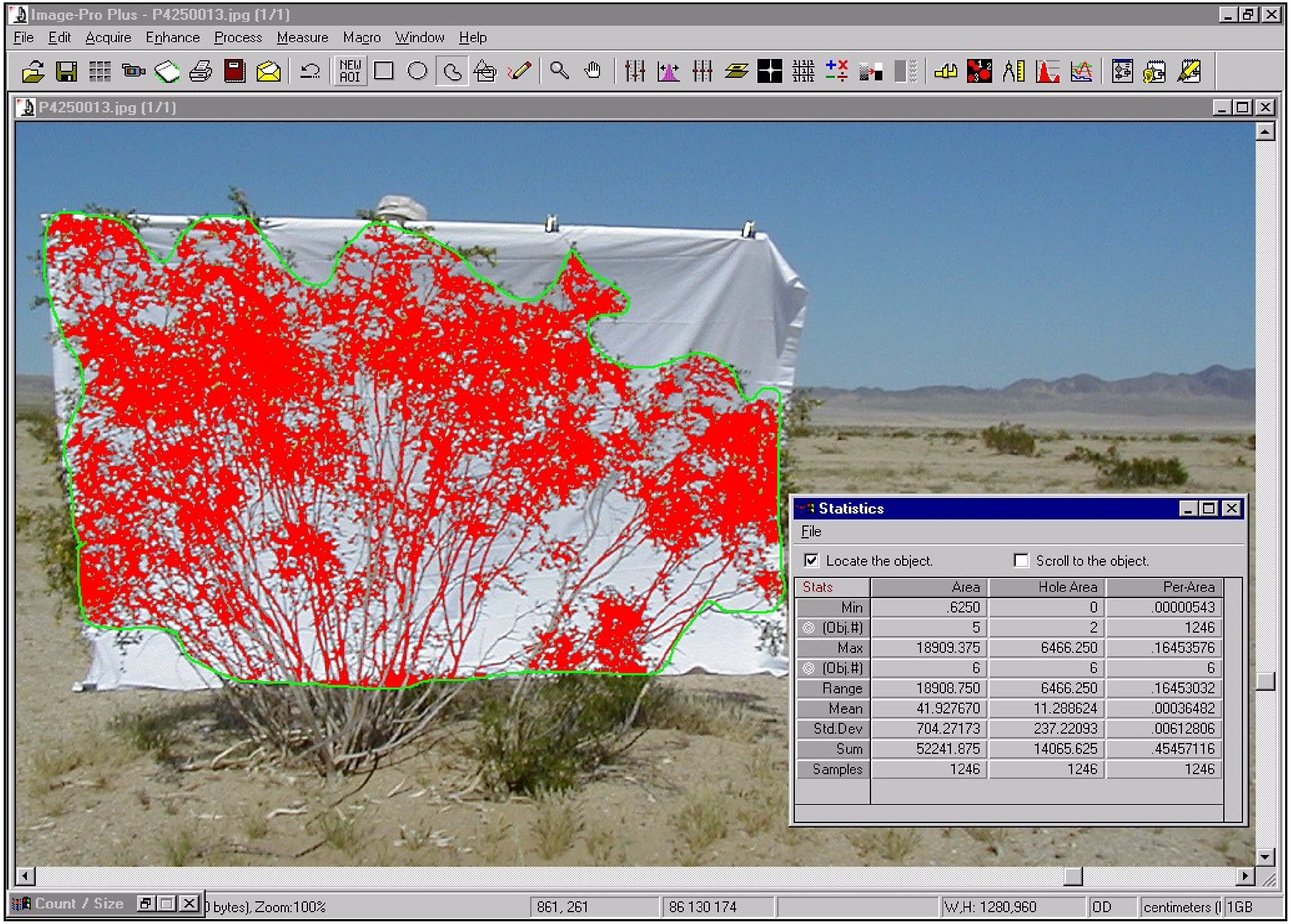


Image-Pro Plus - P4250013.jpg (1/1)
File Edit Acquire Enhance Process Measure Macro Window Help
NEW AOI
P4250013.jpg (1/1)
Statistics
File
Count / Size
bytes), Zoom:100%
861, 261
86 130 174
W,H: 1280,960
OD
centimeters (I
1GB

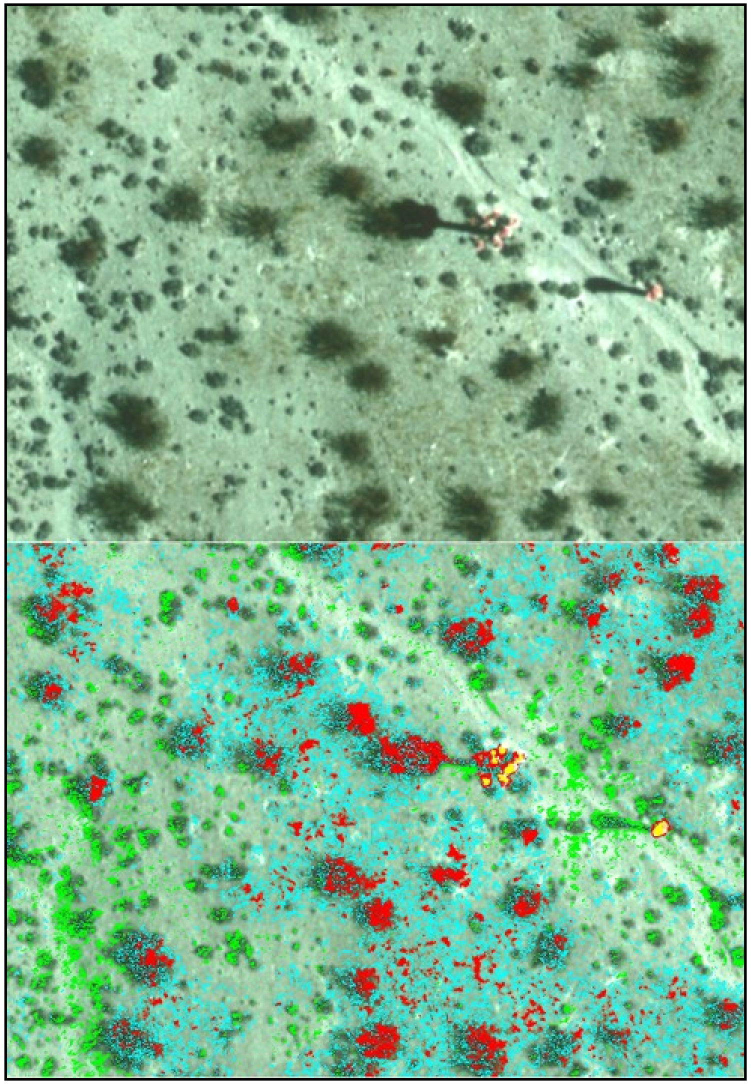
☑ Locate the object. ☐ Scroll to the object.

Stats	Area	Hole Area	Per-Area
Min	.6250	0	.00000543
◎ (Obj.#)	5	2	1246
Max	18909.375	6466.250	.16453576
◎ (Obj.#)	6	6	6
Range	18908.750	6466.250	.16453032
Mean	41.927670	11.288624	.00036482
Std.Dev	704.27173	237.22093	.00612806
Sum	52241.875	14065.625	.45457116
Samples	1246	1246	1246

Calculating Foliar Density of Creosote bush at Fort Irwin

Applications

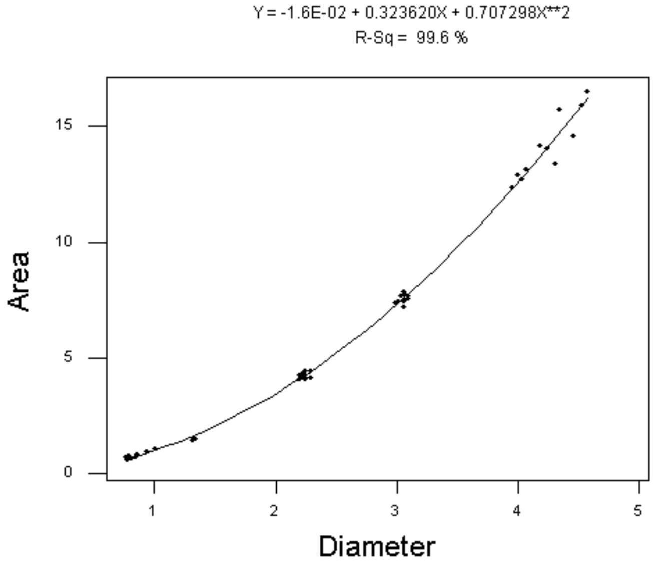
NTS Species Identification



Added Discriminate Power

- **Different colors**
- **Different sizes**
- **Different phenology**
- **Plant parameter correlations**

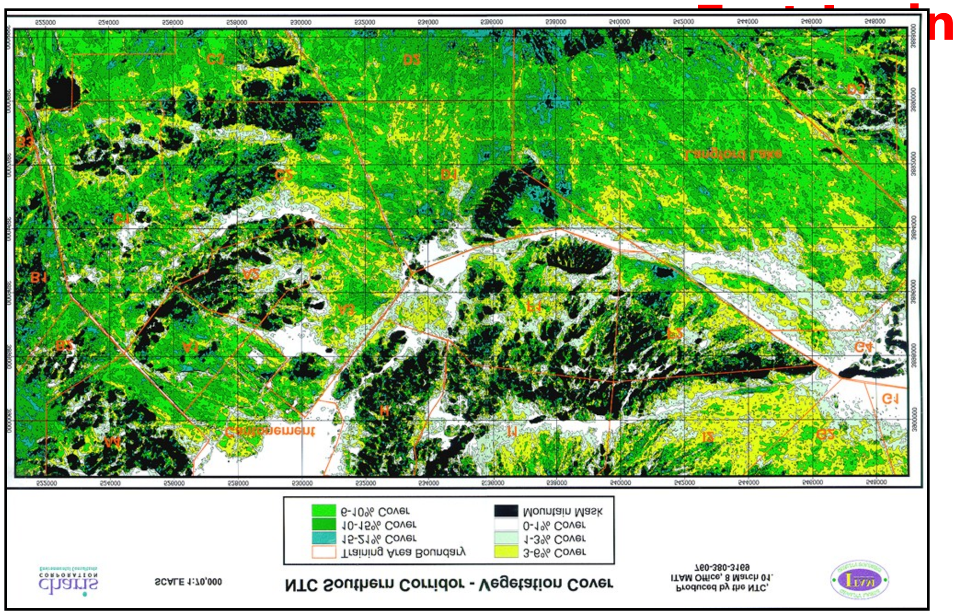
Mean Diameter vs. Mean Area for NTS Shrubs



Bechtel Nevada

Technology Transfer

n, C



C3
D2
B3
C2
D1
Langford Lake
B1
A1
A4
Cantonement
H
I1
I2
C4
G1
G2
6-10% Cover
10-15% Cover
15-21% Cover
Training Area Boundary
Mountain Mask
0-1% Cover
1-3% Cover
3-6% Cover
charis CORPORATION
SCALE 1:70,000
NTC Southern Corridor - Vegetation Cover
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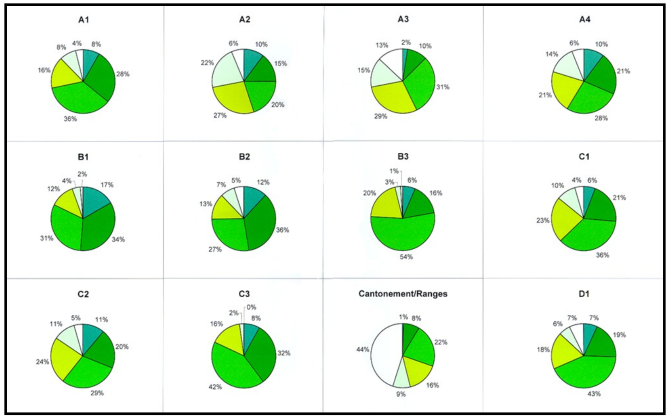
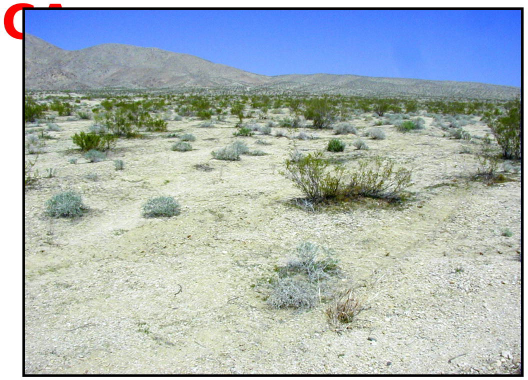
GIS Coverage

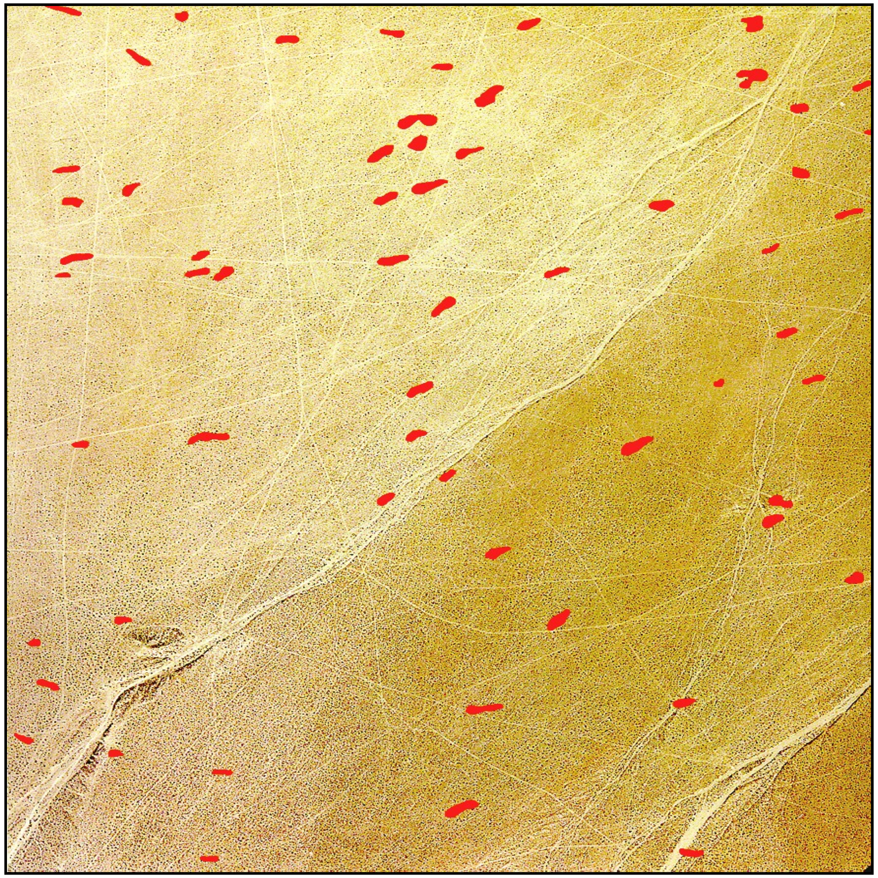


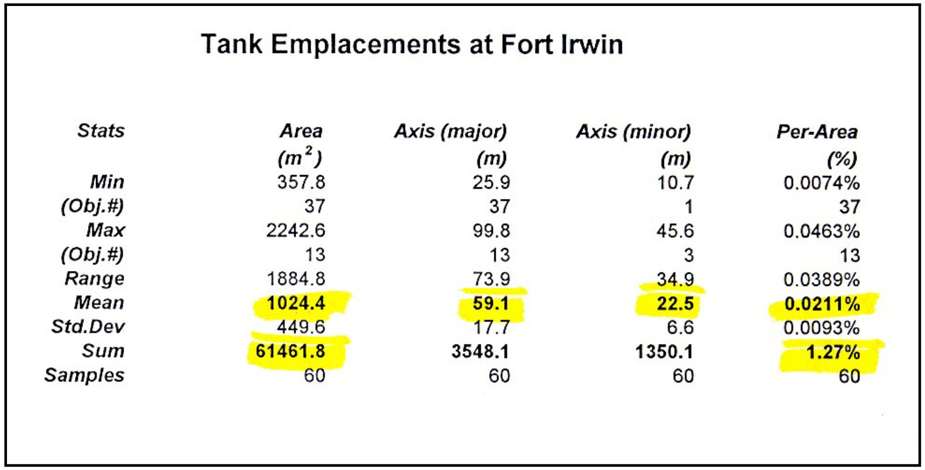
Training Range Condition



Technology Transfer

Tank Emplacements at Fort Irwin, CA



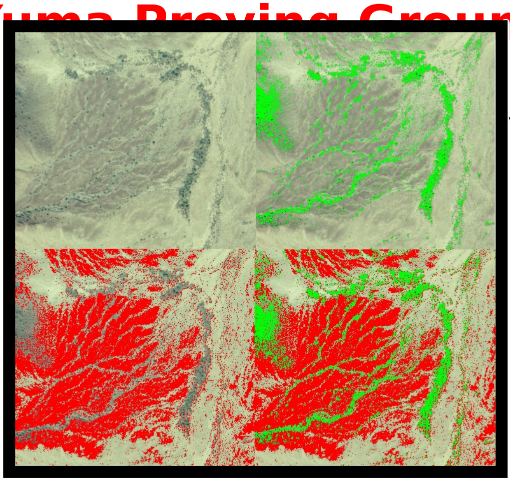


Tank Emplacements at Fort Irwin

Stats	*Area* *(m^2)*	*Axis (major)* *(m)*	*Axis (minor)* *(m)*	*Per-Area* *(%)*
Min	357.8	25.9	10.7	0.0074%
(Obj.#)	37	37	1	37
Max	2242.6	99.8	45.6	0.0463%
(Obj.#)	13	13	3	13
Range	1884.8	73.9	34.9	0.0389%
Mean	**1024.4**	**59.1**	**22.5**	**0.0211%**
Std.Dev	449.6	17.7	6.6	0.0093%
Sum	**61461.8**	**3548.1**	**1350.1**	**1.27%**
Samples	60	60	60	60

Technology Transfer

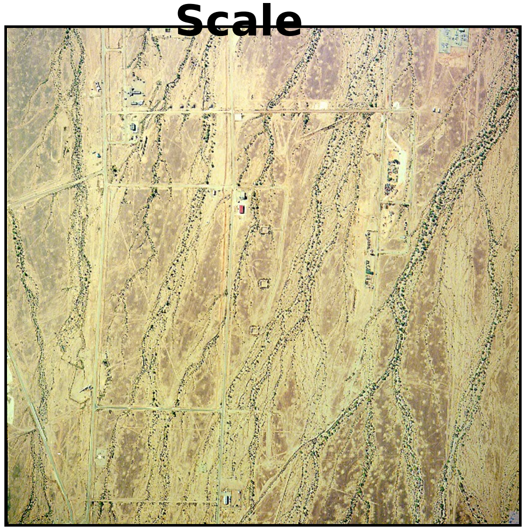
Yuma Proving Grounds, AZ



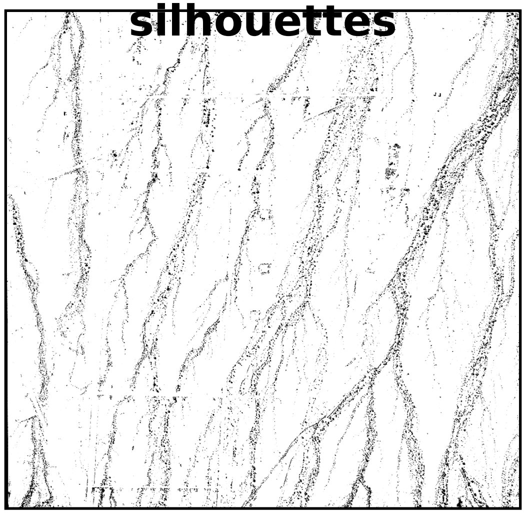
Vegetation

Desert Pavement

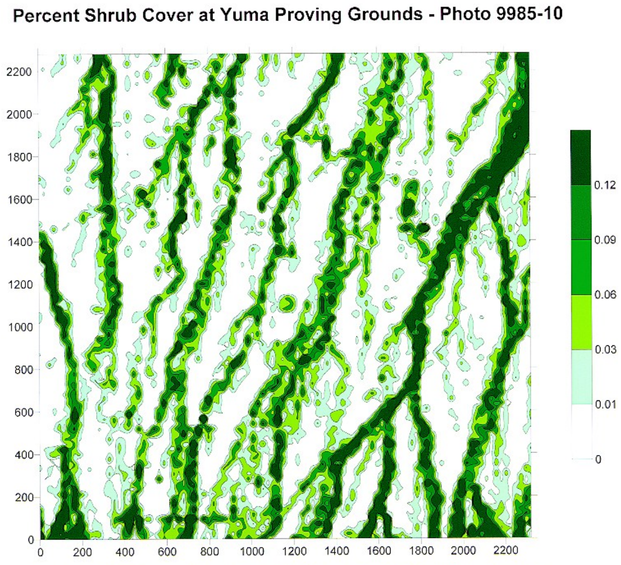
Aerial Photo 1:6000 Scale



Shrub silhouettes



Automated map



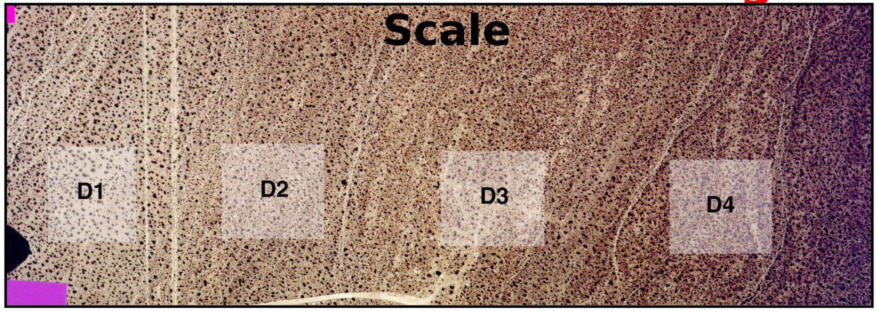
(Minimum curvature; Grid Size 10 X 10 pixels; Axis: number of pixels)

Natural Color → **SigmaScan Pro** → **Surfer 7**

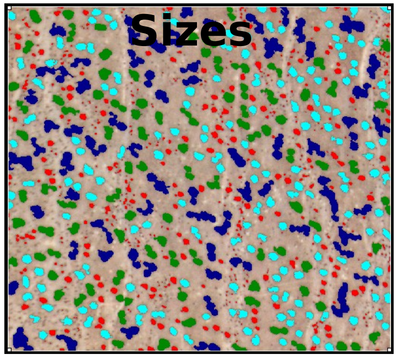
Technology Transfer

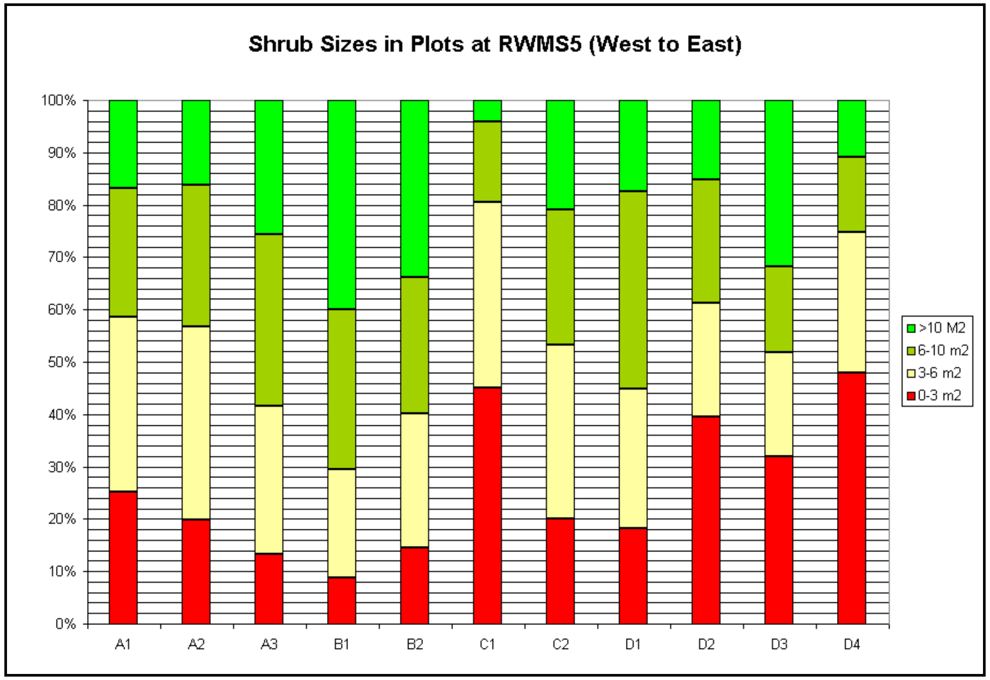
NTS - Area 5 Radioactive Waste Management Site

Aerial Photo 1:4000 Scale



Shrub Sizes





Shrub-size composition

NTS Termites

Technology Transfer

User's Manual

DoD EPA DOE SERDP
Strategic Environmental Research and Development Program
Improving Mission Readiness Through Environmental Research

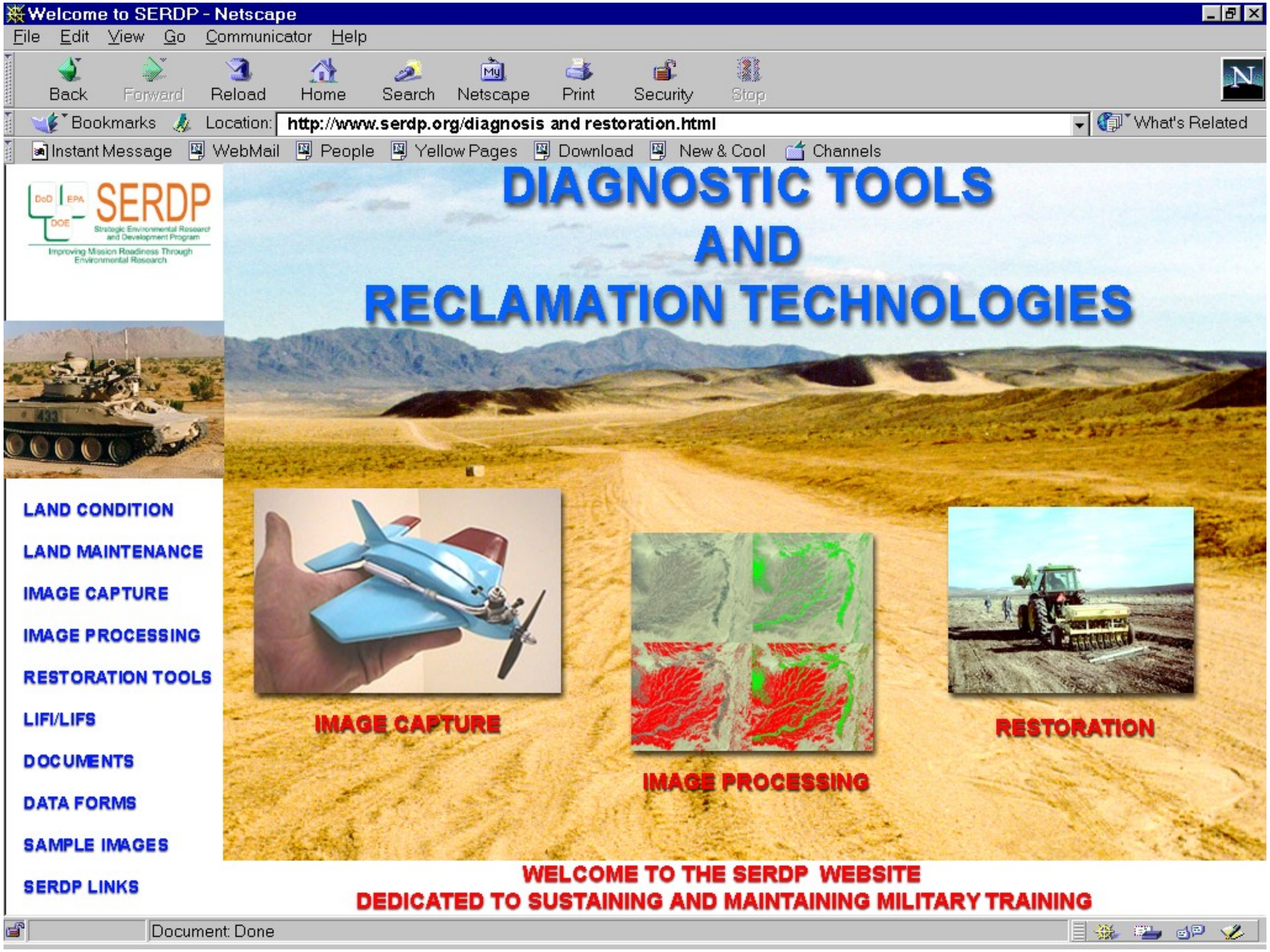
DoD/DOE/BN/11718-2000

SERDP USERS MANUAL

New Technologies
to
Assess Vegetation Change
and to
Reclaim Arid Lands

Technology Transfer

Web Site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Location:
What's Related
Instant Message WebMail People Yellow Pages Download New & Cool Channels
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433
Document: Done

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